המוסד למדעים במדעי הטבע ובטכנולוגיה
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# AN AC VOLTAGE STABILIZER

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## INTRODUCTION

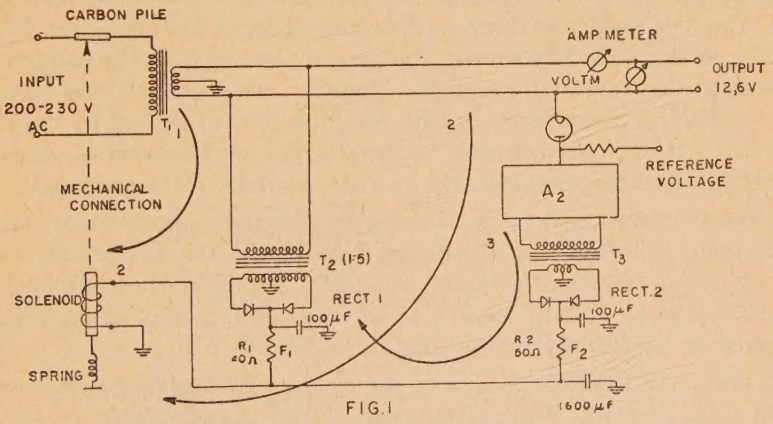
Several AC voltage stabilizers have been recently described [1,2,5,6,9,10]. It is believed, however, that this regulator may be of interest because of its relatively large regulation factor, its very short response time, low weight and independency of frequency.

The regulator contains three electronic valves. An eventual failure of these, causes a large reduction of the regulation factor but only a small (less than 10%) increase in the output voltage.

In the form described the regulator is intended to supply filament current for a great number of valves of an instrument.

## FUNCTIONAL DESCRIPTION OF THE CIRCUIT

The circuit (Figure 1) consists essentially of a conventional regulator circuit (adapted for AC operation) with a carbon pile variable resistor as control element[7,8] which constitutes together with the amplifier $A_2$ a degenerative closed loop.




Functional diagram of the regulator.

Let us consider first the regulator without the amplifier $A_2$, i.e. the local feedback loop denoted by 1. The usual filament transformer $T_1$ receives its input from the mains through a carbon pile variable resistor. The output is sampled by a two-way selenium rectifier, providing the current for the operation of the solenoid. A spring associated with the solenoid acts as a reference.

The ability of this degenerative closed loop to reject external influences (such as changes in input voltage or load conditions) is determined by its open loop gain, which is fairly small.

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A practical way to improve the regulation factor is to employ an external reference and use the pile merely as a control element. This has the added advantage that it decreases the changes in output brought about by ageing or other changes of the mechanical reference.

Consider now the diagram neglecting the local feedback through the two-way rectifier 1 (loop 2 in Figure 1). The output voltage is compared with a constant DC voltage and the sharp peaks so obtained are amplified by $A_2$. The rectified and filtered output of the amplifier actuates the solenoid.

The inevitable filter chain following the amplifier mainly determines the frequency for which the open loop phase shift reaches 180°. The general requirement that the open loop gain should decrease so as to be less than unity for this frequency, limits the permissible amplification of $A_2$. If the amplification exceeds this limit, low frequency oscillations occur. Hence only a very small improvement in the regulation factor can be achieved.

However, a satisfactory arrangement can be obtained by combining feedback loops 1 and 2. This arrangement has the following advantages:

1. The amplifier has to supply only the changes of voltage on the solenoid, the considerable bias power being supplied directly by the transformer.
2. It assures that whenever $A_2$ fails to work the regulated voltage does not change by more than 10%, although the regulation will deteriorate considerably.
3. It makes it possible to obtain a greater loop gain than that obtainable in a single loop. The local feedback (loop 1) does not influence the regulation factor significantly, as the directly returned voltage can be neglected in comparison with the voltage that returns through $A_2$. However, the regulator may be considered as a single loop (denoted by 3) with the loop gain decreased by the local feedback (loop 1). It is thus possible to increase the amplification of $A_2$ and with it the regulation factor considerably over the limit set for a single loop.

This can also be understood by considering the effective impedance, which the filter $F_2$ "sees" at point 2. In the case of external disturbances this is evidently the passive impedance appearing between this point and earth. On the other hand, in the case of internal disturbances (eventually leading to oscillations) the effective impedance is the passive impedance divided by the loop gain of the local loop 1.

It is seen that local feedback facilitates stabilization by decreasing the overall gain. At the same time, however, it preserves some of the characteristics of the previous greater loop gain. This characteristic of local feedback may be of general interest[3].

## DETAILED DESCRIPTION OF THE CIRCUIT

The resistance of the carbon pile (Delco Remy Spec. No. 9432276A) used varies between 3.5 and 55 ohms, the bias voltage necessary for the solenoid being 5 volts. Since the resistance of the solenoid is approx. 5 ohms, it requires a power of approx. 5 watt for actuating it.

The maximum permissible dissipation of the pile is 75 W, thus the maximum load current for a variation of the mains of 15% (200—230 V) is $I_{max} = 75\ W/30\ V = 2.5\ A$ in the primary or 45 A on the load side.

The minimum load current is a function of the maximum resistance, in our case $I_{min}$ = 30 V / 55 ohm = 0.5 A or approx. 10 A on the load side. Because of the minimum resistance of 3.5 ohm, power is dissipated even if the mains voltage is at minimum; thus the maximum permissible current is somewhat smaller than that calculated.

$T_2$ is a 1:5 transformer necessary in order to obtain a DC voltage greater than 5 volt, as otherwise addition with resistance mixing would be impossible.

The comparison circuit employs a (6AL5) diode. It is fed directly with the regulator output.

The gain in $A_2$ required for a given regulation factor could be lower if the diode cathodes were connected to the primary of the transformer and the reference voltage raised accordingly. However, this would increase the output impedance of the regulator by the stray inductivity of the transformer.

The amplifier (Figure 2) is a conventional one with a twin $T$ selective network (Figure 2b) in a regenerative loop[4] around the second valve in order to transform the sharp peaks into a sinusoidal voltage. This is done in order not to overdrive the grid of the output valve, which is required to furnish a given amount of power.

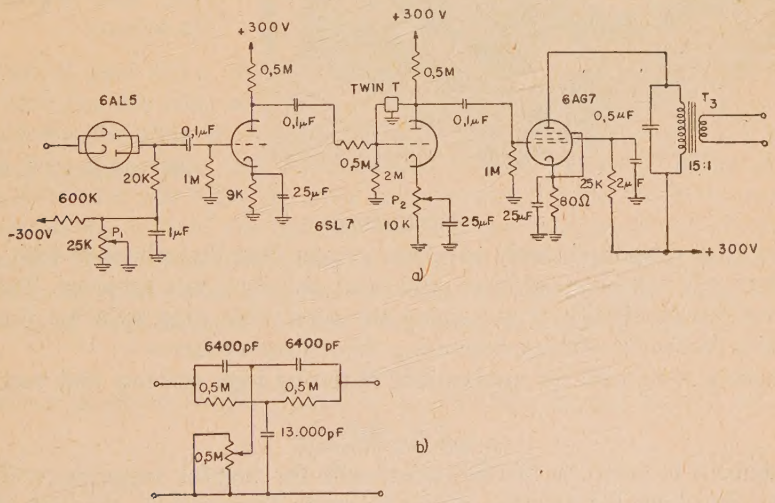


FIG. 2

a) The amplifier $A_2$; b) the twin T selective network.

To minimize the effect of noise picked up by the twin $T$ network the second and not the first stage was made selective.

Potentiometer 2 in the cathode of the second valve provides a convenient means for varying the amplification of $A_2$. This adjustment makes it possible to obtain the largest regulation factor which will still leave a reasonable margin of safety from oscillations.

Two meters are provided to measure the output voltage and current. The reference is obtained from an electronically regulated power supply contained in the instrument for which the regulator was intended.

Potentiometer 1 makes possible small changes in the output voltage by adjusting the reference voltage.

## PERFORMANCE

The following performance data were obtained in actual use. In the input voltage range of 200 to 230 volt and with an output current from 10 to 30 A, one found an almost constant regulation factor of 35. (It may be remarked that without the additional feedback loop 2, this was only 3). The output impedance is 0.002 ohms and the response time 0.1 sec. A decrease of 20% in the amplification of $A_2$ caused a similar decrease in the regulation factor; the output voltage, however, was increased by only 2%. The regulation is effected on the peak-value of the output voltage. An undistorted input voltage is therefore desired. This is always the case for conventional mains.

The regulator has been in constant use for a year and has proved reliable in service.

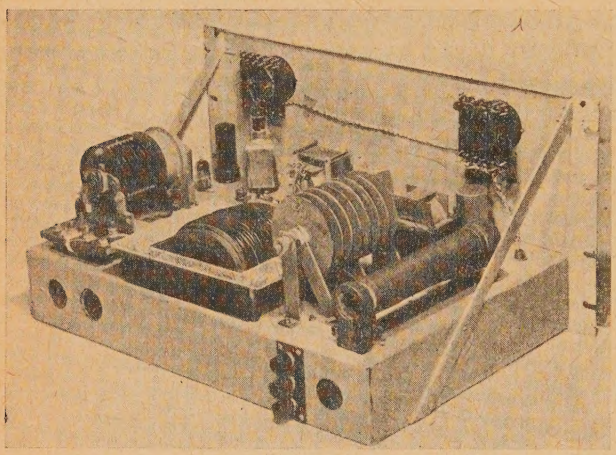

Figure 3
The completed instrument.

## CONCLUSION

A regulation factor approximately ten times greater than that obtained with a conventional carbon pile regulator (without additional circuitry) was achieved. The arrangement utilizes the possibility of increasing the admissible loop gain by provision of local negative feedback, without decreasing the regulation factor.

The regulator is suitable for applications requiring high currents and very constant voltage.

## ACKNOWLEDGMENT

Acknowledgment is made to Mr. I. Cederbaum for helpful suggestions. This work was carried out under the auspices of the Scientific Department, Ministry of Defence of Israel, and is published with its permission.

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# MEASUREMENTS OF THE ELECTRIC POTENTIAL GRADIENT OF THE ATMOSPHERE *

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## INTRODUCTION

Systematic measurements of the atmospheric electric field at ground level were made in Jerusalem from October 1952 to December 1953 to find out whether there exists a correlation between relative humidity and field strength, and to investigate the behaviour of the potential gradient during sharav (khamsin) conditions.

## DESCRIPTION OF METHOD

The instrument used was a Wulf bifiliar electrometer. One terminal of the instrument was grounded and the other connected to a weak radioactive probe of about 10 microcurie, made of a thin plate of silver plated with polonium. The probe was at a height of 1.20 m from the ground and well insulated from it. The range of the electrometer was from 20 to over 300 volts, the error not exceeding 5 volts. All daily measurements were made on the roof of the building housing the Department of Physics, and at approximately 11.00 hours local time, i.e. 09.00 G.M.T. Each measurement consisted of 6 readings taken at about 2 minute intervals, the average value being taken as the final result. The measurements in Table I may serve as a typical example.

TABLE I

*Measurements of the electric potential gradients of the atmosphere on April* 29, 1953. *Rel. Hum.* 21%, *Temp.* 75°F.

| *Hour* | *Reading of electrometer* | *Volts* |
|---|---|---|
| 11.17 | 50 | 88 |
| 11.21 | 49 | 82 |
| 11.23 | 50 | 88 |
| 11.25 | 47 | 72 |
| 11.27 | 49 | 82 |
| 11.30 | 45 | 66 |
| Average | | 80 |

The humidity was measured with a wet and dry bulb hygrometer. In addition to the daily measurements, a few other investigations were made, among them: 1) variation of the potential with height, 2) horizontal component of the electric field, 3) measurements during thunderstorms.

* This paper is part of a research project of the "sharav" (khamsin) phenomenon and its effects on the performance of textile mills in Israel.

Received September 14, 1954.

## RESULTS

### *A. Daily variations of potential*

Figure 1 shows the daily variations of the potential and the relative humidity from October 20, 1952, to October 30, 1953. Though most investigators have been unable to detect any correlation between humidity and potential (Humphreys 1940) and our experimental data are still too limited to allow any definite statements, our measurements show that, for rather extended periods, humidity and potential gradient change together and in the same direction, i.e. a change towards higher relative humidity is followed by an increase in potential and vice versa. This is especially marked during the following periods: November 7—24, 1952, February 6—17, 1953, March 13—25, 1953, May 12—28, 1953, June 1953, July 1953 (with the exception of the 15th, when a sudden rise in potential occurred), September 1953 (with a few exceptions) and October 1953 (with a few exceptions). This relation is especially pronounced during sharav periods, when humidity as well as potential gradient are exceptionally low. Among the well over 30 sharav days recorded there appear only two exceptions to this rule: March 10, 1953, and April 12, 1953.

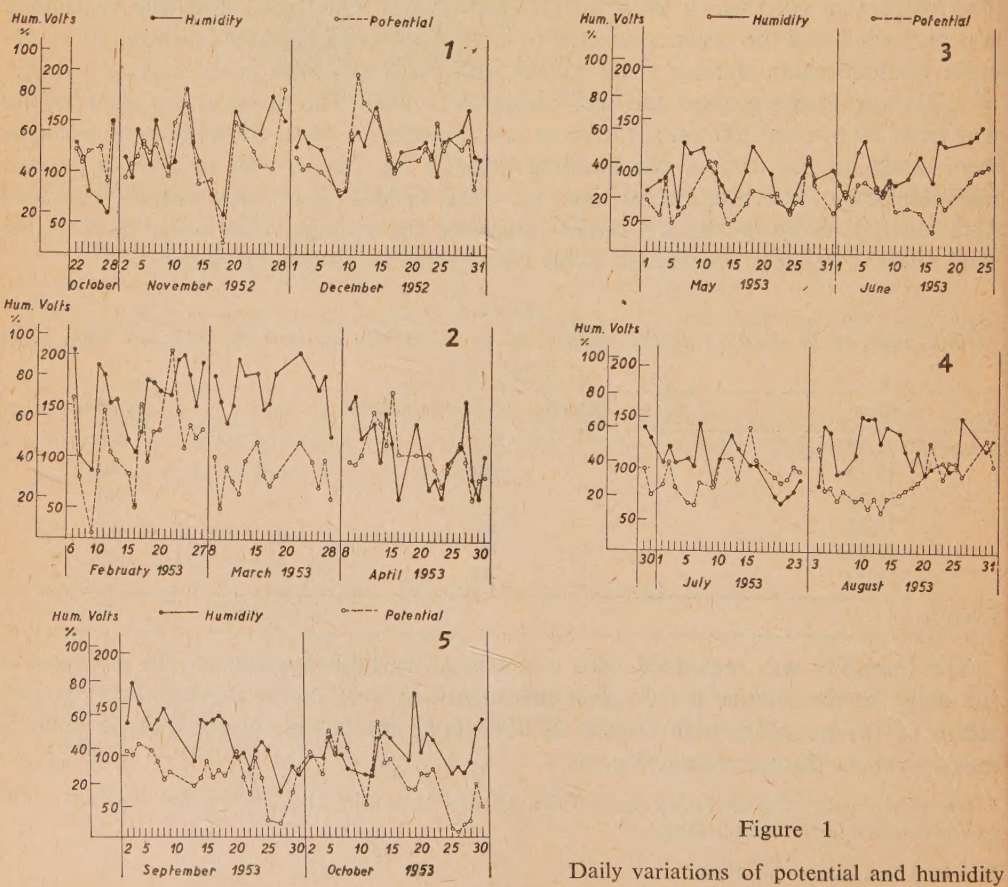


Figure 1

Daily variations of potential and humidity

### *B. Monthly variations of potential*

From the foregoing measurements the average potential for each month was calculated (Table I).

TABLE II

*Monthly average potentials*

| | 1952 | | | 1953 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Month* | *Oct.* | *Nov.* | *Dec.* | *Feb.* | *March* | *April* | *May* | *June* | *July* | *Aug.* | *Sept.* | *Oct.* |
| Volts | 120 | 120 | 121 | 114 | 85 | 103 | 71 | 79 | 95 | 89 | 82 | 78 |

In general, the annual variation of the potential gradient shows an increase during the fall and early winter, followed by a rapid decrease during spring to a moderately constant summer minimum (Humphreys 1940).

### *C. Variation of potential gradient with height*

These measurements were made on sites remote from any buildings and the same instruments were employed. The radioactive probe was placed at various heights above the ground and for every height six readings were recorded, one every 2 minutes. The results of three measurements are given in Figure 2. The first was made on April 28, 1953, during sharav conditions, at the former landing ground near Kfar Shaul, and the other two were made on two consecutive days—June 23 and 24, 1954 — at the Mamilla Cemetery, Jerusalem. It is usually assumed that, near the surface, the potential gradient is 100 volts per metre.

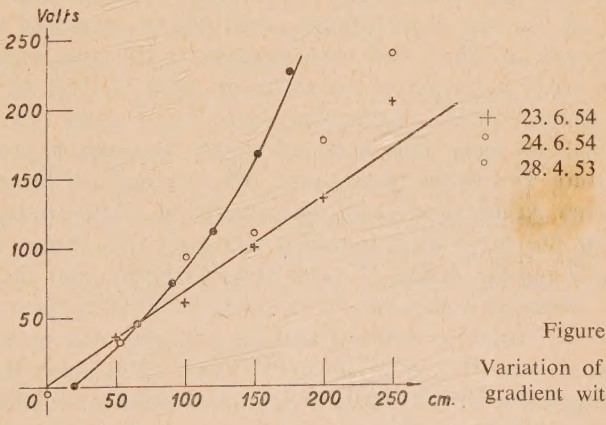


Figure 2

Variation of potential gradient with height

### *D. Horizontal component of the electric field*

It is by no means obvious that the lines of force of the earth's electrostatic field enter the surface at right angles, i.e. that the field is perpendicular to the surface of the earth. Measurements were made to detect any horizontal component of the field. Two radioactive probes were placed at a distance of about 5 metres from one another and at exactly the same height from the ground. One probe was connected to the case of the electrometer and the other to the fibres. The two probes were first placed in the north-south direction and then the position of the outer probe was changed, so that the line through the probes made an ever increasing angle with the original north-south direction. Careful measurements were made at 8 different positions. Though these

measurements were repeated at two different localities, both remote from any buildings, no potential difference between the two probes was observed and therefore no horizontal component of the electric field detected. It might be of interest to add that, when these measurements were repeated on the roof of the Department of Physics and the probes placed at a certain direction, a potential of 20 volts between the probes was observed. This shows clearly that the lines of force are considerably deviated near buildings.

*E. Measurements during thunderstorms*

Though our instruments were ill-suited for these measurements, as raindrops almost immediately "short-circuited" the polystyrene insulators, in some instances two typical "thunderstorm effects" were observed. Those two effects were a) reversal of sign of the potential gradient, and b) sudden and sharp rise in potential.

A reversal of sign could be easily detected by connecting a high voltage battery in series with the electrometer and observing the change in its reading. The earth is usually charged negatively with respect to its surroundings, i.e. the lines of force extend outwards from the centre of the earth. On February 23, 1953, at 10.54 hours, a reversal of sign was observed, the potential changing from + 150 to —190 volts in less than one minute. No rain was falling during this time, but the sky was entirely covered with low cumulus clouds.

On October 31, 1952, at 11.00 hours, successful measurements were made during a thunder- and hailstorm. A sharp and sudden rise in potential to well over 500 volts was observed, but the exact voltage could not be measured as it exceeded the range of the electrometer, which had been increased to 500 volts with the help of a battery. A very significant phenomenon was observed on April 23, 1953. At 13.43 the sky was covered with 5/10 strato-cumulus, temperature was 74.5° F, and relative humidity 21%. The potential was 60 volts, but increased slowly and almost steadily, reaching 82 volts at 13.55 hours, 98 volts at 14.40 hours, 160 volts at 15.07 hours and well over 300 volts at 15.14 hours. At this time the sky was covered by 10/10 strato-cumulus, a few raindrops were falling, but the relative humidity was only 27%. From 15.23 hours onwards the potential fell rapidly, being 32 volts at 15.45 hours, and then rising again, but very unsteadily, changing sometimes by as much as 60 volts (from 82 to 23 volts) in 2 minutes. The sky remained overcast and the humidity was slowly increasing, being 30% at 16.00 hours and 37% at 17.30 hours. From 16.30 hours the readings became more steady, being about 70 volts at 16.30 hours, 120 volts at 17.00 hours and then decreasing slowly to 82 volts at 17.30 hours, when measurements were broken off. These observations prove again that changes in weather have a remarkable influence on the electrostatic potential of the earth, a fact well-known but not quite understood.

Sudden changes in potential, reversal of sign, etc., have been noted many times by different observers and are mentioned in the references cited.

## THEORETICAL CONSIDERATIONS

There seems to be a surprisingly good correlation between humidity and potential gradient. To our knowledge, no such correlation has been published by other investigators. Since the scope of the above measurements is limited, it is too early to draw any final conclusions, and the following theoretical considerations are therefore preliminary.

Under stationary conditions (i.e. time-independent current and spacecharge) the potential gradient $E$ is connected by Ohm's law with the specific conductivity $\lambda$ and the current density $I$:

$$E = I/\lambda \tag{1}$$

We can assume that the potential difference $V$ between the highly conducting earth and the likewise well conducting stratosphere is independent of local conditions, and, as a first approximation, the same may be assumed for the integral resistance per cm² $R$ between these equipotential levels at the place of measurement.

Under these assumptions, the current density $I = V/R$ would be nearly constant, and the potential gradient $E$, according to (1), proportional to $1/\lambda$.

The special geographic situation of our station, between the Mediterranean Sea and the Arabian Desert, normally favours rather homogeneous and well defined air movements, high humidity corresponding to air coming mostly from the sea, lower humidity to air with normally a higher percentage of air from the desert.

It is well known that at ground level air conductivity is influenced strongly by radioactivity, which is much higher on land than over the ocean.

High humidity, i.e. air coming mostly from the sea, should therefore in our case correspond to lower radioactivity and consequently lower conductivity. Under our assumptions this would result in higher potential gradients.

In this way, the good correlation between humidity and potential gradient could in our case be understood as a result of especially favourable meteorological conditions.

The following contrary arguments should be mentioned: a) the assumption of constant resistance/cm² $R$ may be unjustified, especially in our case of rather homogeneous air movements; b) conductivity on ground level is generally influenced rather strongly by the existence of slow ions which tend to reduce the conductivity. As this influence is also stronger on land, and opposite in sign to the influence of radioactivity, the above considerations are only justified if the number of slow ions is small.

It follows from the above that only more frequent measurements at a greater number of stations and for a longer period — and especially synchronous measurements of air conductivity, number and kinds of ions, etc., would allow final conclusions.

## CONCLUSIONS

Measurements of this kind are usually carried out with self-recording instruments, giving a continuous reading throughout the day. As no such instruments were available, we were forced to use the rather primitive method described. The potential gradient is greatly modified by fog, rain and other, non-meteorological precipitations as smoke and dust clouds. These influences may be recognized on self-recording instruments, especially when coupled with wind observations, conductivity measurements, etc., but cannot be detected so easily when making isolated measurements at fixed hours. For this reason all measurements were "spread out" over 10 minutes, and, though this certainly helped in obtaining a "true" average value, it was far from being fool-proof. (The sudden rise in potential occurring on December 11, 1952, is a good example of a "non-representative" measurement). The only practical remedy lies in increasing the number of daily measurements. One year is much too short a period for reaching any definite conclusion about the relationship between the potential

gradient and the various meteorological elements, but, as no such measurements have been published yet in the Middle East, our results may serve as a useful hint for any future research in this field.

ACKNOWLEDGMENTS

From October to December, 1952, all measurements were carried out by S. Rosendorf, who also helped in devising the equipment. The authors wish to express their sincere gratitude to Mr. Levinson for constructing and maintaining the instruments. The initial stages of this investigation have been partly financed by a grant from the Textile Research Association.

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# NOTES SUR LES *CHRYSOLININI* (*COLEOPT., CHRYSOM.*) DE LA MEDITERRANEE ORIENTALE

JAN BECHYNÉ
*Museum G. Frey, Munich*

Mon honoré Collègue, le Dr. H. Bytinski-Salz, m'a généreusement confié un matériel intéressant de *Chrysolinini* (*Chrysomelini* auct.) capturé par lui-même dans l'Israel, présentant plusieures nouveautés faunistiques et taxonomiques. Grace à sa gentillesse il était possible d'effectuer une révision du matériel déterminé se trouvant dans les collections de la Division de Protection des Végétaux, Ministère d'Agriculture, et de la Maison Gordon à Deganya (leg. J. Palmoni [Palm.]). Selon ce matériel examiné jusqu'à présent, je pense de ne pas commettre de grandes erreurs en rayant les espèces suivantes, qui se trouvent dans le "Prodromus Faunae Palestinae" (Caire 1937) du Prof. F. S. Bodenheimer, dont les déterminations n'étaient pas correctes:

| | | |
|---|---|---|
| (*Chrysomela sacrarum* Weise) | = | *Chrysolina palmyrensis* n. sp. |
| ( " *porphyrea* Fald.) | = | *Crosita compuncta* Weise |
| ( " *orientalis* Oliv.) | = | *Chrysolina halysa* Bech. |
| ( " *sahlbergi* Mén.) | = | *Chrysolina halysa* Bech. |
| ( " *aegyptiaca* Oliv.) | = | *Chrysolina marginata sanguineocincta* Cr. |
| ( " *hyrcana* Weise) | = | *Chrysolina marginata sanguineocincta* Cr. |
| ( " *morio* Kryn.) | = | *Chrysolina peregrina impavida* Bech. |
| ( " *hyperici* Forst.) | = | *Chrysolina didymata syriaca* Weise |
| ( " *didymata* Reiche) | = | *Chrysolina didymata syriaca* Weise |
| ( " *aeneipennis* Reiche) | = | *Crosita compuncta* Reiche |
| (*Colaphellus apicalis* Mén.) | = | *Colaphellus palaestinus* Achard |

De la liste des 16 espèces de *Chrysomela* et *Colaphellus* donnée par Bodenheimer 10 devaient être eliminées et 8 nouvelles espèces, non-mentionnées y, ont été ajoutées. Par conséquent le nombre actuel de ces espèces en Israel est 14. Il est probable qu'un certain nombre supplémentaire d'espèces rencontrées en Egypte et au Liban se trouveront aussi en Israel. J'ai ajouté également quelques notices complémentaires sur les formes habitant la Méditerranée Orientale.

*Crosita* (*Bittotaenia*) *grata* Falderman

Un exemplaire (♀) provenant de Damas (Syrie 3.V. 1952, leg. Seidenstuecker, Mus. G. Frey) diffère des exemplaires typiques (de l'Asie centrale) par la taille plus large et la ponctuation générale plus grossière.

*Crosita* (*Bittotaenia*) *compuncta* Weise

Israel: Jerusalem 31.XII, Giv'at Brenner 16.XI, Manara 3.XII (leg. Bytinski-Salz [BySl]), Hadera 13.VII (Palm.).

Received August 15, 1954.

*Chrysolina* (*Threnosoma*) *anceyi* Mars. ssp. *winkleri* Breit

Liban: Hadeth 1—20.VII.1952.

*Chrysolina* (*Menthastriella*) *coerulans* Sriba ssp. *angelica* Reiche

Israel: Tel Aviv—Yarqon River 6.X, on *Mentha* (ByS), Nabi Rubin 26.VIII (I. Aharoni), Binyamina 29.V, Geva' I (ByS), Migdal 19.V (Gruenberg), Huliot 18.X (Shoham), Metulla 21.VII (Gruenberg).

Jordan: Amman 30.VIII, Jericho 31.I (P. A. Buxton).

Liban: S. Hermil 2.VII.1952.

Cette forme n'est connue que d'Israel, Jordan, Liban et Syrie (Alep, Damas).

*Chrysolina* (*Erythrochrysa*) *polita* ssp. *polita* L.

Israel: Hule: Melaha 14.V, Hulata 2.VII (ByS), 26.IV—3.VII (Palm.).

Liban: S. Hermil 2.VII.52.

*Chrysolina* (*Colaphoptera*) *blanchei* ssp. *blanchei* Fairmaire

Israel: Jerusalem 20.XII, Binyamina—Kabara 16.XI, Carmel 3.I, Yagur 28.IV (ByS), Carmel 2—28.V (Tapuchi).

Liban: Harresa 22.XI.1952; Syrie: Krak de Chavelier 18.V.1952.

*Chrysolina* (*Ovosoma*) *halysa* ssp. *halysa* Bechyne (1950, Ent. Arb. Mus. G. Frey I, p. 127)

Israel: near Jerusalem 20—30.I (Buxton), Jerusalem 31.XII—16.II (ByS), 27.XI (Palm.), Carmel 2—28.IV (Tapuchi), Ramat Gan spring, 'Afula 17.XII (Palm.).

Liban: Harajel 16.XII.1952.

*Chrysolina* (*Minckia*) *peregrina* Herr. Schaeff. ssp. *impavida* Bechyne

Israel: Zikhron Ya'aqov 31.IV (Fishelson), Elon 5.IV (ByS), Tiberias Hot Springs 20.III, Deganya 25.III (Palm.).

*Chrysolina* (*Taeniosticha*) *dohrni* ssp. *dohrni* Fairmaire

Liban: Ain Zhalta 23.XI.1952.

*Chrysolina* (*Centoptera*) *bicolor* Olivier

Israel: *f. nigropunctata* Reitter: Ramat Gan spring (Palm.), Negev: 15 km S. de Beersheba 25.XII, Revivim 8.IV, Subeita 9.IV, Kfar Yeroham 11.IV, Gvulot 8.IV (ByS), Bir 'Asluj 18.VII (Palm.). — *f. regalis* Olivier: Tel Aviv—Yarqon River 21.V, Ramat Gan 6.VI (ByS), spring (Palm.).

Cette espèce est aussi largement répandue dans toute l'Afrique du Nord.

*Chrysolina* (*Hypericia*) *didymata* Scriba ssp. *syriaca* Weise

Israel: Mefalsim 21.IV (Vermis), Ascalon IV, Barbara 16.IV, on *Hypericum*, Giv'at Brenner 18.III, on *Hypericum* (ByS), Rehovot 13.IV (Hecht), Sarafand 18.IV, on *Hypericum*, Bnei Braq 21.III (ByS), Carmel 3—10.V (Tapuchi), Elon 24.IV (ByS).

*Chrysolina* (s.str.) *gypsophilae* Kuest. ssp. *lucidicollis* Kuest.

Israel: Rishon le Zion 28.I (Palm.), Hanita 17.IV (ByS).

*Chrysolina* (*Chalcoidea*) *vagecincta* Fairmaire

Cette espèce, abondante en Algérie, vient se placer dans le sousgenre *Chalcoidea* Motsch. Elle ressemble extrêmement au *Chr. aegyptiaca* (voir ci-dessous) dont elle diffère par la base des antennes nettement rapprochée au bord externe du clypéus et

par la conformation spéciale des tarses chez les ♀ ♀ . L'aedeagus est semblable à celui de *Chr. marginata* L., mais la protubérance apicale est beaucoup plus courte.

*Chrysolina* (*Chalcoidea*) *marginata* L. ssp. *sanguineocincta* Crotch (**nov. comb.**)

Israel: Kfar Yeroham, 1.VI, Subeita 9.IV, sur *Achillea*, Gvulot 18.IV (ByS).

Décrit de Sinai comme espèce distincte. La diagnose originaire était répétée par Bedel en 1908 (Abeille 31, p. 55; citation omise dans les catalogues). Il ne représente qu'une race géographique de *Chr. marginata* L., proche (même par la conformation de l'aedeagus) à la subsp. *bodemeyeri* Weise, dont il diffère, outre la ponctuation du prothorax plus faible et celle des élytres plus forte, par le dimorphisme sexuel bien plus marqué: chez la race *bodemeyeri* le corps est sensiblement allongé chez les deux sexes, offrant peu de différences dans les dimensions. Chez la subsp. *sanguineocincta*, le ♂ a la même taillle comme le ♂ de la subsp. *bodemeyeri*, mais la ♀ est largement ovalaire et notablement plus grande, dépassant 8 mm de longueur.

La seule ♀ examinée du Liban (Ain Zhalta 23.XI.1952, American Univ., Beirut) ressemble beaucoup à la ssp. *bodemeyeri* Weise (habitant Iran), mais à sculpture élytrale beaucoup plus fine et bien plus éparse. L'examination du ♂ est nécessaire pour une détermination exacte.

*Chrysolina* subg. **Diachalcoidea** subg. nov.

Genotype: *Chrysolina saccarum* Weise.

Caractères généraux:

Epimères du prosternum carénés. Dernier article des palpes maxillaires ovalaire, plus large et bien plus long que le précédent, de la même forme chez les deux sexes. Tarses du ♂ dilatés, le 1er article aussi large que le sommet des tibias correspondants, le 3e article des tarses antérieurs presque aussi large que le 1er; le même article des tarses intermédiaires est sensiblement plus étroit que le 1er et, enfin, le 3e article des tarses postérieurs est à peine plus large que le 2e et moitié aussi étroit que le 1er. Dernier segment abdominal du ♂ robuste, plan, très obsolétement excavé au milieu, coupé en ligne droite en arrière. Epipleures non dilatés, bien visibles de côté en toute leur longueur. Ponctuation élytrale disposée en 8 séries longitudinales régulières, plus ou moins géminées (+ une série longitudinale scutéllaire raccourcie et une autre, juxtasuturale, série juxtamarginale très obsolète). Insectes ailés, de la taille moyenne, èlytres bronzés, bord latéral et apical rouge ou testacé. Calus latéral du prothorax faiblement convex, faiblement limité. La base des antennes se trouve exactement au milieu entre le bord antérieur de l'oeil et le bord extérieur du clypéus.

Distribution géographique: Asie centrale, Asie mineure, Egypte, Lybie.

Ce sousgenre est proche aux *Chalcoidea* Motsch., dont il diffère outre la taille courtement ovalaire et fortement convexe par la position de la base des antennes.

Il se compose des espèces suivantes:

1(2) Angles antérieures du prothorax aigus, taille grande, de 7.5—8.5 mm . . .

. . . *Chrysolina* (*?Diachalcoidea*) *rufomarginata* Baly

Iraq. [Species invisae. Il pourrait appartenir même au subg. *Chalcoidea*.]

2(1) Angles antérieurs du prothorax largement arrondis. Taille inférieure de 7 mm.

3(6) Taille ovalaire (♂) ou trés courtement ovalaire (♀).

4(5) Séries longitudinales de points sur les élytres nettement géminées, intervalles larges presque deux fois aussi larges que les étroits. Chez la ♀, les 3 premiers articles de tous les tarses sont munis d'une large ligne dénudée au milieu. Partie antérieure de l'aedeagus dilatée près de la base de l'ouverture préputiale. Long. 5—7 mm (*Chr. incognita* Jacobson i.l.)...

... *Chrysolina* (*Diachalcoidea*) *saccarum* Weise

Turkestan, Iran, Afghanistan, Pamir.

5(4) Séries longitudinales des points sur les élytres obsolètement géminées, la différence entre les intervalles larges et étroits fait moins que 20%. Chez les ♀♀, c'est seulement le 1er article des tarses postérieurs qui est faiblement sillonné en dessous. Côtés de l'aedeagus parallèles, graduellement rétrécis à partir de la base de l'ouverture préputiale...

... *Chrysolina* (*Diachalcoidea*) **palmyrensis** sp. géogr. nov.

a. Plus grand, de 5.5 à 7 mm, points des séries longitudinales des élytres peu profonds . . .

... *Chr. palmyrensis* ssp. **palmyrensis** ssp. nov.

Typus: Lebanon: Palmyra, XI.1937 (F. Tippmann, Mus. G. Frey).
Paratypes: Israel: 5 km South of Kallia 15.II, Jericho 6.XII—23.II, Jerusalem I—5.IV (ByS), near Jerusalem 20—30.I.22 (Buxton), Gvulot 18.IV, Rafa I (ByS), Nahalal 26.V, Kinneret 2.IV, Deganya 12—22.III, 11—14.XI, Sha'ar Hagolan 20.XI, 'Ein Gev 13.II (Palm.).

b. Plus petit, ± 6 mm, ponctuation élytrale profondément insculptée . . . .

... *Chr. palmyrensis* ssp. **assurensis** ssp. nov.

Typus: Iraq: Assur (coll. F. Hauser > coll. F. Stoecklein, Mus. G. Frey).

6(3) Taille longuement ovalaire chez les deux sexes. Séries longitudinales de points sur les élytres équidistantes sur le disque, nettement géminées aux côtés. 1er article de tous les tarses de la ♀ longitudinalement dénudé en dessous . . . .

... *Chrysolina* (*Diachalcoidea*) *aegyptiaca* sp. géogr.

a. Plus grand, env. 7 mm. Calus latéral du prothorax à peine convexe . . . .

... *Chr. aegyptiaca aegyptiaca* Olivier

Egypte, Lybie.

b. Plus petit, ± 6 mm. Calus latéral du prothorax très distinctement convexe . . .

... *Chr. aegyptiaca* ssp. **aleppensis** ssp. nov.

Typus: Syrie: Alep (coll. J. Breit, Mus. G. Frey).

Cette dernière forme pourrait être retrouvée en Israel.

*Chrysolina* (*Palaeosticta*) *numida* Reiche

Israel: Ramat Gan spring (Palm.), Herzlia 15.III, Binyamina 17.XI, Kfar Vitkin 12.III (ByS), Hadera I, Ginegar (Palm.).

Espèce largement répandue en Afrique du Nord, n'étant pas encore signalée d'Israel.

# THE SAWFLIES (*HYMEN., SYMPHYTA*) OF ISRAEL

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During the last few years I have received from Dr. H. Bytinski-Salz for determination several very fine and valuable collections of sawflies from Israel and these have considerably increased our knowledge of this little known fauna. Taking Bodenheimer's (1937) list as a basis, one family (*Xyelidae*) and 36 species are reported as new for Israel (indicated by*), including 6 new species and subspecies, the diagnoses of which have already been published in a separate paper (Benson 1954). Besides the collections mentioned above, I have also been able to study material by the collectors listed below and also to re-examine and rectify material from the collection of the Department of Agriculture of the Government of Palestine. Most of all this material is now in the collection of the British Museum (Natural History).

Collectors on whose records the list is based, and the years during which the specimens I have seen were collected: I. Aharoni (1920—27), C. H. Andrewes (1953), E. E. Austen (1915—18), F. S. Bodenheimer (1938), G. B. Bodkin (1927), I. N. Brair (1942), P. A. Buxton (1923), H. Bytinski-Salz (ByS) (1942—53), A. Gruenberg (1931), G. F. Hucklesby (1925—26), Middle East Biological Study Scheme (M. E. B. S. S.) (1945), F. D. Morice (1909), J. Palmoni (1936—44), O. Schmiedeknecht (1909), Y. Tapuchi (1929), J. Wahrman (1945—47), K. P. Whitehorn (1915).

Though so far about 75 species of sawflies seem to be known from Erez Israel, probably only the smaller part of the actual fauna has so far been recorded. Many of the species require humid conditions and should therefore be looked for during the spring rains. Many feed on the flowers of *Umbelliferae*, and a considerable fauna will probably ultimately be found attached to the coniferous trees and the oaks in the hills.

Near East sawflies of families other than the *Tenthredinidae* (i. e. *Pamphiliidae*, *Megalodontidae*, *Cephidae*, *Xyelidae*, *Siricidae*, *Xyphidriidae*, *Orussidae*, *Argidae* and *Cimbicidae*) can often be identified with the help of Gussakovskij's work (1935—47). Of the *Tenthredinidae*, many of the species can be found in Enslin (1912—18), and all the genera at least and many references in Benson (1951—52).

## SIRICIDAE

*Urocerus gigas* (L.)

Bodenheimer (1930) mentions 2 specimens, Nahalal and 'Ein Gedi 1924, probably introduced with timber. In the collection of the Agricultural Experimental Station, Rehovot, there is 1 ♀ specimen without locality, to which however one of the 2 specimens mentioned above probably refers. Bytinski-Salz, who re-examined this specimen for me, affirms that it belongs to the Central European *U. gigas* ssp. *gigas* (L.) and not to *U. gigas argonautorum* (Sem). or *U. augur* (Klug), which may have been expected to occur locally.

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**Paururus dux* Sem.

1 ♀ caught alive in Tel Aviv 15. V. Probably introduced with coniferous timber from Transcaucasia via the Black Sea (det. ByS. i. litt.)

**Xeris spectrum* (L.)

Tel Aviv, from pine timber imported from Yugoslavia. VIII (ByS). Europe, Caucasus to Siberia.

XYELIDAE

**Xyela graeca* (J. P. F. Stein)

Jerusalem, Botanical Garden on Mt. Scopus (ByS), Jerusalem (Bodenheimer). II—III. France, S. E. Europe, Asia Minor, Algeria. *Pinus*. I have already pointed out (Benson 1938) that *X. graeca* is a valid species and not a synonym to *X. julii* Breb.

MEGALODONTIDAE

*Tristacus judaicus* (Lep.)

Jerusalem, Binyamina, Alonim, Elon (ByS), Tiberias (Andrewes and Palmoni). III—IV. Syria.

**Megalodontes escalerai* Kon.

Rehovot (Aharoni). IV. S. Europe, Asia Minor.

**Megalodontes imperialis* Kon.

Migdal, on *Bupleurum subovatum* (Palmoni), Deganya, 'Ein Gev, Lakhish, Hatsor (ByS). IV—V. Asia Minor.

**Megalodontes phoenicius* Lep.

Urim, Kfar Yeroham on *Haplophyllum tuberculatum* (ByS). VI. Transcaucasus, Asia Minor, Syria.

CEPHIDAE

**Syrista parreyssi* Spin.

Binyamina, Elon, Amir (ByS). III—IV. S. Europe, E. Mediterranean, Cyprus, to Caucasus.

**Pachycephus sanctus* (Pic.)

Jaffa (Hucklesby), Tel Aviv, Dorot, Beersheba, Tiberias (ByS), Kinneret (Palmoni), Upper Galilee (Hucklesby). III—IV. Endemic. The reference of *P. smyrnensis* Stein in Bodenheimer (1937) probably refers to this species.

**Pachycephus konowi* Kohl.

Urim (ByS). V. Asia Minor.

*Trachelus libanensis* (André)

Jericho, Miqve Israel, Binyamina (ByS), Mt. Tabor (Brair). III—IV. Syria. *Gramineae*.

**Trachelus judaicus* (Kon.)

Jerusalem (Morice and Schmiedeknecht). III. Endemic. *Gramineae*.

*Trachelus tabidus* F. ssp. *macilentus* F.

Jerusalem, Beersheba, Carmel (Khreibe), Alonim, Elon, Hanita, Nahalal (ByS), 'Ein Gev (Sussita) (Palmoni). III—V. All Europe to Caucasus, Cyprus, N. Africa, Asia Minor. *Gramineae*, including cultivated forms.

**Trachelus armenius* Kon.
Tiberias (ByS), Deganya (Palmoni). III—IV. Cyprus, Asia Minor, Transcaucasia.

*Cephus pygmaeus* (L.)
Jericho, Jerusalem, Miqve Israel, Holon, Ra'anana, Wadi 'Ara, 'Afula, 'Ein Harod (ByS), Tiberias (Whitehorn), Deganya (Palmoni), Rosh Pina (ByS). III—IV. Europe and N. Africa, to Turkestan, Asia Minor and Iran. *Gramineae*, including cultivated forms.

*Calameuta idolon* (Rossi)
Shfeya, Nahalal (ByS), Tiberias (Palmoni). II—IV. N. Africa, Mediterranean Coast, Cyprus, Asia Minor, Caucasus. *Gramineae.*

**Calameuta pygmea* (Poda)
Jericho, Elon (ByS), Deganya (Palmoni). II—IV. N. Africa and S. W. Europe. ?*Gramineae.*

**Calameuta apicicornis* (Pic.)
Jerusalem (ByS). IV. Endemic. ?*Gramineae.*

ARGIDAE

*Arge ochropus* (Gmel.) (syn.: *rosae* auctt.)
Jerusalem (ByS, Palmoni, Wahrman), Sahel Ifgim (Wahrman), Daphne Oaks (ByS). III, V, VIII. All Europe to C. Asia and N. Iran, Cyprus. *Rosa.*

**Arge frivaldzkyi* (Tischb.)
Qiryat 'Anavim, Dan (ByS). III—V. S. E. Europe to Caucasus and Syria.

**Arge* ? *nigritarsis* (Klug)
Elon (ByS). III. Cyprus, Syria, Talysh, N. Iran.

**Arge scita* Mocs.
Jerusalem (Austen, ByS, Palmoni, Tapuchi), Bethlehem (Bodkin), Qiryat 'Anavim (ByS), Upper Galilee (Gruenberg). III—VIII. S. E. Europe, Asia Minor, Syria. Two specimens (Jerusalem, Upper Galilee) determined as *A. proxima* André also belong to *A. scita* Mocs., but the true *A. proxima* described from the Lebanon may also be expected in Israel.

**A. rustica* L.
Carmel (Khreibe Oaks) (ByS). IV. C. and S. Europe, Caucasus, Asia Minor.

**Sterictiphora furcata* (Vill.)
Urim (ByS). V. C. and S. Europe, N. Africa, Asia Minor.

**Aprosthema* spec.
Miqve Israel, Ra'anana, Elon (ByS). At least two different species are represented in this material, but the taxonomy of this genus is in such a state that a generic revision would be necessary to determine these specimens.

**Kokujewia palestina* Bens. (1954, p. 277)
Western shore of the Dead Sea (Wadi Umbarrik) (Type); larvae on *Emex* (ByS). III. Endemic.

CIMBICIDAE

*Palaeocimbex quadrimaculata* (Muell.) ssp.
Jerusalem, Qiryat 'Anavim, Betar, Hartuv, Bet Lid, 'Ein Harod (ByS). Usually raised from larvae. II—V. S. Europe and Asia Minor. *Amygdalis*, *Prunus*, *Crataegus*, *Pirus*. The Israeli form is usually attributed to *F. humeralis* Geoffr., but, as several distinct forms seem to occur in the Mediterranean, a more exact determination is impossible at the moment.

**Corynis amoena* (Klug)
Carmel. IV. N.E. and S. Europe.

**Corynis orientalis* (Konow)
Jerusalem—Jericho road at sea level, dto—Old Wadi Kelt Police Station, Jerusalem (ByS). II—III. N. Iraq.

*Corynis similis* (Mocs.)
Carmel (Place of Sacrifice) (Tapuchi). IV. Syria, Cyprus, Crete, Ionian Islands.

**Corynis reticulata* Benson (1954, p. 273)
Sha'afat near Jerusalem (Austen) (Type). III. Endemic.

TENTHREDINIDAE

*Selandriinae*

**Dolerus kokujewi* Konow
Jerusalem, Miqve Israel, Bror Hayil (ByS), Beer Tuvia (Wahrman), Caesarea (Buxton), Haifa (ByS). II—III. E. Europe from C. Russia. ? *Gramineae*. The determinations of *D. gonager* F. in André (1881) and Bodenheimer (1937) probably refer to this species.

*Monostegia abdominalis* (F.)
Deganya. III. Europe to Siberia, Asia Minor.

*Allantus didymus* (Klug)
Jerusalem, Binyamina, Haifa, Alonim, 'Ein Gev (ByS). III—IV. S. Europe.

**Athalia cuspidata* Benson (1954, p. 277)
Jerusalem (Type, Paratypes) (ByS). IV—V. Endemic.

**Athalia glabricollis* Thoms. ssp. *meridiana* Benson (1954, p. 279)
Jordan (Place of Baptism, Jericho) (Paratypes), Jerusalem, Wadi Ghar, Jaffa, Gat (Paratypes) (ByS), Naqb Sehali (Wahrman). II—IV. Israel, Asia Minor, Iran (Types).

**Athalia cordata* Lep.
Bror Hayil, Qvutsat Schiller, Ramat Gan, Hadera (ByS). I—III. Europe and Mediterranean to Transcaucasia, Cyprus. *Ajuga*, *Antirrhinum*, *Plantago*, etc.

*Athalia rosae* (L.) (syn. *colibri* Christ.)
Tiberias (ByS), Deganya, on flowering cauliflower (Palmoni). I—III. Europe to Siberia, N. Africa, Asia Minor.

*Caliroa cerasi* (L.)

Qiryat 'Anavim (ByS). VI. Probably Eurasian in origin but now introduced to all temperate parts of the world. Trees, especially cultivated *Prunus* and *Pirus*.

*Fenella judaica* (Forsius) (1930, as *Paraphyllotoma judaica* gen. et spec. nov.)

Jerusalem (Tapuchi) (Type). Endemic.

*Nematinae*

*Hoplocampa flava* (L.)

Qiryat 'Anavim, Abu Ghosh, Dahlia, Ramat Hashofet (ByS). III—IV. Europe to Caucasus and E. Mediterranean. *Prunus*.

**Cladius ordubadensis* Kon.

Miqve Israel, Haifa (ByS). III—V. Caucasus, Crimea, Cyprus.

**Nematus capreae* (L.)

Tel Aviv, Yarqon river on *Salix babylonica* (ByS). VII. C. Europe.

*Tenthredininae*

**Sciapteryx cleopatra* Benson ("*S. costalis* F." det. Forsius) (1954, p. 284)

Jerusalem 1929 (Types), Egypt.

**Sciapteryx lactipennis* Kon.

Kfar 'Etsion, 1 ♀ 5.II.47 (Wahrman). Transcaucasia, Iran, Transcaspia.

*Elinora maculata* (Kriechb.) (syn. *syriaca* André)

Jordan (Place of Baptism, Jericho) (ByS and Wahrman), Wadi Ghar, Beersheba, Deganya (ByS), Wadi Fejjas, Kinneret (Palmoni). II—IV. Syria.

**Elinora nigritarsis* (Kon.)

Meged, Haifa (ByS). I—IV.

**Tenthredopsis convergens* Benson (1954, p. 282)

Elon 1 ♂ (Type) (ByS). VII. Endemic.

*Tenthredopsis albonotata* André

Jerusalem, Bab el Wad, Ra'anana (ByS), Hadera, Mt. Gilboa', Deganya, Kinneret (Palmoni), Tiberias (ByS). II—III, IX. Greece, Asia Minor. The ♂ ♂ from Mt. Gilboa', Kinneret and Tiberias have an entirely black abdomen.

*Tenthredo similis* Mocs. (syn.: *nazarensis* André)

Jerusalem (ByS and Gruenberg), Rehovot (Aharoni), Nir 'Am, Bet Lid, Ya'arot Hacarmel (ByS). II—IV. Asia Minor to Iran.

**Tenthredo vittata* Kriechb.

Jaffa district (Hucklesby, Austen), Ramle (Aharoni). II—IV. Syria.

**Tenthredo costata* Klug

Jerusalem, Qiryat 'Anavim, Dorot, Carmel, Kinneret (ByS), Tiberias (Palmoni). IV—VII. S. E. Europe to Syria and Caucasia.

*Macrophysa postica* Brullé

Jericho (Austen), Holon, Bet Lid, Binyamina (ByS), Zikhron Ya'aqov (Buxton), Mt. Carmel (M. E. B. S. S.), Matsuba (Wahrman), Deganya, Migdal, Daphne (ByS). III—IV. S. Europe to Syria.

*Macrophysa consobrina* Mocs.

Miqve Israel, Binyamina, Mt. Carmel, Alonim, Nahalal (ByS). II—IV. Syria.

**Macrophysa parvula* Kon.

Mt. Carmel (ByS). III. Europe to Syria.

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# ON THE *BETHYLOIDEA* (*HYMEN.*) OF ISRAEL

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During a number of years I received from Dr. H. Bytinski-Salz, Tel Aviv, several shipments of Bethylids for determination, which are the more interesting as they constitute the first comprehensive collection of this little known group from the Middle East. The list comprises 22 species, to which 3—4 more mentioned in the text must be added. Nevertheless this number will account for only a part of the species to be expected in Israel.

Most of the species are parasites of Coleopterous larvae, some also of Lepidopterous larvae, while the *Dryinidae* parasitize Homoptera. Much could still be done by systematically breeding these hosts (especially woodboring larvae) for parasites.

Even if it was not always possible to determine the material specifically, I thought it of value to mention such specimens in the present list so as to draw the attention of later students to the presence of these forms in Israel. I have refrained from describing any new species in this paper, as this in part would have necessitated the revision of many genera on a "whole world" basis, and a comparison with the original material of Kieffer and Picard, now scattered throughout the museums of Europe.

Very little can be said in regard to the composition of the fauna, which, as a whole, seems to be Mediterranean, but 2 species, *Sclerogibba embiidarum* (Kieff.) and *Epyris pilosipes* Kieff., are so far known only from the Tropics.

## SCLEROGIBBIDAE

*Sclerogibba embiidarum* (Kieff.)

Tel Aviv, 15—20.IV, 2 ♀, Meged, 3.IX, 1 ♀. These specimens seem to agree well with Kieffer's species which was bred in Ceylon from the Embiid, *Oligotoma greeniana* End. (Richards 1939), and is also known from India.

## BETHYLIDAE

*Cephalonomia hypobori* Kieffer *in* Picard, 1919

Rehovot, parasite of *Hypoborus ficus*, 2 ♂ 2 ♀ (det. Ferriere). These specimens are in Canada balsam on a slide and as far as can be seen are probably correctly identified.

*Cephalonomia tarsalis* (Ashmd.)

Tel Aviv, 1.VI, "in wheat infested by *Calandra* and *Tribolium*", 6 ♀. This species is a well known cosmopolitan parasite of the beetle, *Oryzaephilus surinamensis* (L.)

*Cephalonomia* sp.

Tel Aviv, 10.VIII. One specimen, without antennae. This is a rather large species, with distinct venation, and a very long head.

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*Glenosema pedestris* (Kieff.) (= *Arysepyris pedestris* Kieffer, 1906)

Jerusalem, Ramat Rahel, 18.II, 2 ♀. These specimens agree well with the descriptions but no authenticated material was available for comparison. The species is recorded from Corfu and Tangier. Berland (1928) has shown that the two genera are the same. A female of an apparently different species of the genus was captured at Jerusalem, 27.VII.

*Sclerodermus domesticus* Klug

Tel Aviv, 7.II, ex *Cupressus*, 1 ♀, 17.II, 1 ♀; Rishon le Zion, 8.II, ex *Cupressus*, 3 ♀. This is a well-known parasite of wood-boring beetles such as Anobiids and is widespread in the Mediterranean region.

*Israelius carthami* Richards

This new genus and species was described from a long series of specimens bred by Dr. H. Bytinski-Salz with larvae of *Lasioderma serricorne* (Fab.) in Saff flowers (*Carthamus tinctorius* L.) (Richards 1952). The localities included Urim, Revadim, Gat, Gezer, Hulda, Bet Dagon, Tel Tsur and Ayelet Hashahar; during the months July—October.

It is surprising that an insect parasitic on a cosmopolitan beetle is not itself widespread. Mr. K. V. Krombein found a specimen in the collection of the U. S. National Museum, which was intercepted in quarantine in material coming from Greece.

*Laelius fulvipes* Kieff.

Hadera, 17.I, 2 ♀. These females agree best with the description of this species, but the genus requires revision.

*Laelius* sp.

One unidentifiable female of this genus was obtained at Tel Aviv, 1.X.

*Mesitius spathulifer* Picard, 1932

Jerusalem, 15.VI, 1 ♀; 1 ♀ (leg. Theodor). Described from Ghazir, in Syria.

*Mesitius. syriacus* Picard, 1932

Alonim, 23.III, 1 ♀ of this (described from Ghazir) or of some very similar species. Another female (Jericho, 22.VIII) belongs to a third species and seems from the description to be different from *M. judaeorum* Picard 1932, which was described from Jericho. It would be desirable to examine longer series to see the limits of variation, particularly in the shape of the clypeal carina.

*Epyris pilosipes* Kieff.

Jericho, 2.VI, 3 ♀, Jerusalem 1.X, Ramat Gan, 1.VI, 1 ♀, Binyamina 7.V, 2 ♀, Dahlia 3.X, 'Ein Harod, 1. IX, 2 ♀, Nir 'Am, 26.VIII, 5.IX, 1 ♂ ♀. This species was described from Portuguese Guinea, but the above specimens agree well with E. African ones in the British Museum collection.

*Epyris marshalli* Kieff.

Nir 'Am, 21.III, 1 ♀. Probably belongs to this species which is recorded from the south of France. A male with the same data may also belong here. There are also two

females (Jerusalem, 6.VIII, 11.VII) and three males (Nir 'Am, 21.III), which all seem to belong to different species.

*Rhabdepyris* sp.

Rishon Le Zion, 2.VII, 1 ♀. This seems to be a species very distinct from others, but more material is needed to establish its status.

*Holepyris lineatus* Kieff.

Haifa, 4.XII, 1 ♀. This specimen agrees pretty well with the description which is unfortunately not very decisive. It was described from Spain.

*Holepyris. ruficollis* Kieff.

Bat Yam, 21.IV—23.V, 2 ♀. Belongs perhaps to Kieffer's species which was described from Egypt.

*Trachepyris spinosipes* Kieff.

Beersheba, 14.VIII, 1 ♀, Wadi Kelt, 5.IX, 1 ♀. These specimens agree well with the description of Kieffer's species which was described from Algeria.

*Plastanoxus* sp.

Gezer, IX, 1 ♂ 1 ♀, ex flowers *Carthamus*. Apparently distinct from *P. westwoodi* (Kieff.) which is a beetle parasite.

*Pseudisobrachium carpentieri* Kieff.

Fahringer (1930) recorded a male probably belonging to this species from Khudeira (now Hadera). I have also seen a male belonging to this genus from Dahlia, 2.III.

*Bethylus gaullei* Kieff.

Tel Aviv, 30.II, 1 ♀, Qiryat 'Anavim, 30.V, 12 ♀, Jerusalem, 11.VII, 1 ♀. It is convenient to use this name for the Mediterranean species (described from Tangier) with the head shining, very weakly alutaceous, and the ocelli intermediate in position between *B. fuscicornis* (Jur.) and *B. cephalotes* (Foerst.).

*Perisierola gestroi* Kieff.

Haifa, Carmel, 8.II, under pine bark, 1 ♀, Gat, 1.IX, ex *Lasioderma* larva, 1 ♀, Rehovot, 11.VIII, ex *Lasioderma*, 1 ♀, Gezer, IX, ex *Lasioderma* larva, in heads of *Carthamus tinctorius*, 3 ♀. These specimens agree best with *P. gestroi* Kieff. (Sardinia) but might belong to *P. gallicola* Kieff. (Italy). The latter species, however, has been bred from Lepidopterous larvae and would be very unlikely to attack those of beetles.

## DRYINIDAE

*Gonatopus dimidiatus* Sahlberg

This species was described (1910, Acta Soc. F. et Fl. fenn., **33**, No. 7, 17) from a single female captured near Jericho, 13.III.

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# ON THE *EVANOIDEA* (*HYMEN.*) OF ISRAEL

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The majority of the material listed was collected and sent to me by H. Bytinski-Salz, Tel Aviv. F. S. Bodenheimer (1937) enumerates 3 species of *Evaniidae* and 2 of *Gasteruptionidae*, all of which have been verified. In the present paper several species new to the fauna of Israel have been added, so that today 5 *Evaniidae* and 9 *Gasteruptionidae* are known.

The species of *Evaniidae* are all parasites of the oothecae of cockroaches, while the few species of *Gasteruption* which have been bred are parasites of bees.

The genus *Evaniella*, which is known only from the Neoarctic, Neotropical and Australian regions, is here reported for the first time from the Palaearctis. The species of the large genus *Gasteruption* are abundant in the Mediterranean region, but are still greatly in need of revision. Many of the Israel species cannot yet be identified, while others can only be given provisional identification. The most useful paper for the determination of this family is that by Ferrière (1946), on the Swiss species.

## EVANIIDAE

*Evania appendigaster* (L.)

Tel Aviv, 21.VI, ♀. Dr. Bytinski-Salz has many records of this species from the coastal area (Jaffa, Nahariya, etc., V—X), where *Periplaneta* is the common genus of cockroaches.

*Evania dimidiata* Fab.

Haifa 12.VI (det. ByS).

*Prosevania punctata* (Brullé)

Jerusalem, 15.X, ♂, 24.V, ♀, 5.IX, ♀. Dr. Bytinski-Salz knows this species only from old towns, away from the coast, where *Blatta orientalis* L. is common and *Periplaneta* does not occur.

*Evaniella* sp.

Rosh Pina, 30.IX, 1 ♀, leg. Verechson.

This specimen runs down to the genus *Evaniella* Bradley in Townes' key (1949), except that the shoulders do not have a sharp transverse ridge. The species seems very

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distinct but cannot be established without more material. The abdomen, legs and antennae are red and the thorax is slightly red-tinged. The head is coarsely punctate, not shining, and there are two impressed furrows on each side of the face, but no striae. It is quite different from *Evania dimidiata* Fab.

*Brachygaster minuta* (Ol.)

Binyamina, 16—27, 26/7.III, ♂ ♀. I have bred this species in England from the oothecae of *Ectobius*.

GASTERUPTIONIDAE

*Gasteruption dolichoderum* Schlett.

Jericho 11.VI, ♂, Jerusalem, 23.IV—20.VIII, ♂ ♂ ♀ ♀, Tiberias, 12.VII, 4 ♂, 'Ein Gev, 23.IV, ♂, data not recorded, 1 ♀.

This species was decribed from Rhodes but the Israel specimens agree very well with the original description.

*Gasteruption* sp. aff. *jaculator* (L.)

Jerusalem, 29.IV—28.X, ♂ ♂ ♀ ♀ (one ♀ with thorax partly reddish), Tel Aviv 8.V—3.VI, ♂ ♂ ♀ ♀, Ramat Gan, 11.VI, ♂, Elon, 8.V, ♀, Rosh Pina, 3.VII, ♀.

*G. jaculator* (L.) (=*thomsoni* Schlett.) has a more northern distribution and a slightly different head sculpture. The Israel specimens may be no more than a slight geographical variant.

*Gasteruption nigrescerus* Schlett.

Jerusalem, 1.V, ♂ ♀, Daphne, 13.V, on oak. These specimens belong to a variety with the head more shining and the base of the hind tibia dark.

*Gasteruption rubricans* (Guér.)

Jerusalem, 12—20.VI, ♀ ♀, Ramat Hasharon, 19.VII, ♀, Binyamina, 24—26.III, ♀ (darker variety), Nahariya, 7.V, ♀.

This species is known, in Europe, as a parasite of *Prosopis variegata* Fab. (Apoidea) (Stoeckhert 1922).

*Gasteruption pyrenaicum* (Guér.)

Jerusalem, 29.IV, ♀, 6.VI, ♀. The hairy eyes of this species do not warrant placing it in a separate genus (*Trichofoenus*).

*Gasteruption* sp. aff. *variolosum* (Abeille)

Jericho, 20.VII, ♀, Wadi Kelt, 19.VI—5.IX, ♂ ♂, Jerusalem—Jericho Road, km 8, 7.VIII, ♂, Jerusalem, 20.VII, ♂ ♂ ♀, Dorot, 27.XI, ♂, Ramat Gan, 6.V—8.VI, ♀ ♂ ♂, 'Ein Harod, 1.IX, ♂. These specimens do not agree altogether with Kieffer's description of the species, but the whole group needs a revision.

*Gasteruption* sp. aff. *syriacum* Szep.

'Eqron, 3.X, ♂. Perhaps the same as *G. syriacum* which Szepligeti described from Syria.

*Gasteruption pedemontanum* (Tourn.) (=*terrestre* (Tourn.)
Jerusalem, 30.V, ♀. The species is widespread in the Mediterranean region.

*Gasteruption diversipes* (Abeille) (= *granulithorax* Schletterer *nec* Tournier)
Tel Aviv, 10.V—25.X, ♀ ♀ . A common Mediterranean species.

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# VEGETATION OF THE LITTORAL SALT MARSHES IN ISRAEL

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## INTRODUCTION

The few coastal salt marshes in Israel are located within areas having a high water table. The largest of these salines are situated around the lower reaches of the Kishon and Na'aman rivers in the Acre Plain. As vegetation here will be destroyed in the near future in the Kishon Harbour project, study of the plant communities and the factors controlling their distribution seemed opportune.

The named rivers cross heavy transported soils, sandy loams and sand dunes. Accordingly the soil of the marshes under review is not uniform in its mechanical composition.

The climate of the Acre Plain is typical Mediterranean. The average rainfall amounts to 580 mm. The summer months from June to August are rainless, while the average annual for May plus September is 5.2 mm. The mean annual temperature is 19.9°C, the average maximum temperature of the hottest month, August, is 31°C, while the average minimum of January, the coldest month, is 8.4°C. Very seldom does the temperature drop below freezing point.

The main factors controlling plant distribution and composition of associations in saline vegetation are salt concentration and soil moisture. 123 soil samples were taken in late summer in various plant communities and examined for moisture content, total soluble salts, chlorine and carbonate content and *p*H.

The lowest value of total soluble salts was 0.25%, the highest amounted to 5.9%. All the soils examined belong to the white alkali type. Spots of black alkalis were found by Ravikovitch and Bidner (1948) in the adjoining areas. The main component of the soluble salts is NaCl, with $Cl'$ amounting to about 50% of the total soluble salts.

The water table is rather high, varying considerably during the year; in some localities it reaches soil surface even in late summer; the soluble salts content of the ground water varies from 0.042% to 0.148% (Ravikovitch and Bidner 1948).

The water content of the soil is rather high. Its mean values for various plant communities vary from 22.9% to 59.8%, the latter being far above field capacity. The ratio (salt content/water content) × 100 has been calculated, although these values are far from being identical with concentration of the soil solution. The average values of the salt/water ratio for the plant communities were between 3.8 and 10.9.

## SOME REMARKS ON THE VEGETATION AND ITS PHYTOSOCIOLOGICAL ARRANGEMENT

In the 48 records made in 9 plant communities, only 48 species were found, 17 of which were accidentals and encountered only once.

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As in other edaphic habitats exhibiting zonal vegetation, here also there is a continuous transition between adjacent plant associations. This, as well as microtopography, forming secondary microzonal systems within the major zones, renders zonation more complex and distinction between plant associations more difficult. The ordinary way of choosing a quadrat and listing the plant species is, therefore, misleading here to such an extent that one may look in vain for characteristic and differential species. The associations under review have, therefore, been distinguished mainly by their dominant and high presence species.

Ecological data, too, cannot be helpful in this case, because changes in vegetation are generally more abrupt than the changes in the habitat factors, due to competition between the leading species which show overlapping ranges of tolerance to salt concentration and excess of water in the soil.

## THE PLANT COMMUNITIES

In the area under investigation associations of three well established alliances of halophytes have been found. Two of them, the *Salicornion fruticosae* Br.—Bl. 1933 and the *Junceto—Phragmition* Zoh. et Orsh. 1949, show regular and spatially more or less well developed zonation complexes. The third one, the *Thero—Salicornion* Br.—Bl. 1933. is scattered here and there in isolated areas of salines strongly affected by man (irrigation and ploughing), or in patches inundated in winter and left to invasion by pioneering vegetation in late summer. Nowhere do the two associations of this alliance form a zonal complex and seldom do they join any other belts.

The above two zonation complexes are also distinguished by their salt and water relations as shown in Plate III, 5.

The soil of *Salicornion fruticosae* has a smaller water content than that of the *Junceto—Phragmition*. In both, the water and salt content decrease toward the periphery of the complex.

### (1) *Thero—Salicornion* Br.—Bl. 1933

This alliance is represented by two pioneer annual associations. The *Salicornietum herbaceae* inhabits the small areas of the lower part of the marsh, drying out only in summer, while the *Salsola soda—Suaeda splendens* association develops mostly under somewhat segetal and ruderal conditions.

(a) Assoc. of *Salicornia herbacea* Br.—Bl. 1933. This association is very unstable in its floristic composition. In the 9 records taken in this association the following species were found:

Characteristic species and/or differentials of association (Figures represent percentage of presence):

| | |
|---|---|
| *Salicornia herbacea* | 100 |

Characteristic species of class:

| | | | |
|---|---|---|---|
| *Salicornia fruticosa* | 67 | *Polypogon maritimus* | 22 |
| *Cressa cretica* | 44 | *Pholiurus incurvatus* | 11 |
| *Aeluropus litoralis* | 44 | *Hordeum marinum* | 11 |

This being an association of "new" territories, it is not surprising that the data received from the examination of the soil samples taken in 5 stands vary considerably from one another (Table I).

TABLE I

*Soluble salt and water content in the soil of* 5 Salicornietum herbaceae *stands in per cent of dry weight*

| *Depth in cm* | *Total soluble salts* | | | *Cl'* | | | *Water content* | | | (*Sol. salts/water cont.*) × 100 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* |
| 0—20 | 1.66 | 0.32 | 3.67 | 0.67 | 0.14 | 1.71 | 19.7 | 12.9 | 29.5 | 11.3 | 3.6 | 19.4 |
| 20—40 | 1.34 | 0.70 | 2.66 | 0.55 | 0.22 | 1.20 | 24.6 | 19.7 | 28.2 | 3.8 | 2.7 | 5.5 |
| 40—60 | 1.62 | 0.80 | 3.80 | 0.75 | 0.37 | 4.74 | 36.3 | 20.4 | 66.1 | 4.1 | 2.9 | 5.7 |

(b) Assoc. of *Salsola soda—Suaeda splendens* Br.—Bl. 1933. This one is somewhat richer in number of species. In the 6 records taken, the following plants have been listed:

Characteristic species and/or differentials of association:

| | | | |
|---|---|---|---|
| *Suaeda splendens* | 100 | *Atriplex hastata* | 17 |
| *Salsola soda* | 33 | | |

Characteristic species of class:

| | | | |
|---|---|---|---|
| *Polypogon maritimus* | 33 | *Juncus maritimus* | 17 |
| *Phragmites communis* | 33 | *Inula crithmoides* | 17 |
| *Spergularia* sp. | 33 | *Salicornia herbacea* | 17 |
| *Salicornia fruticosa* | 17 | *Cressa cretica* | 17 |

Accidentals:

| | | | |
|---|---|---|---|
| *Cynanchum acutum* | 17 | *Heliotropium* sp. | 17 |

Soil samples were taken in 4 stands. The results of their examination are given in Table II.

TABLE II

*Soluble salt and water content in the soil of* 4 Suaeda splendens *stands in percent of dry weight*

| *Depth in cm* | *Total soluble salts* | | | *Cl'* | | | *Water content* | | | (*Sol. salts/water cont.*) × 100 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* |
| 0—20 | 2.73 | 2.17 | 3.52 | 1.39 | 1.06 | 1.74 | 26.9 | 8.7 | 52.9 | 16.6 | 4.7 | 27.8 |
| 20—40 | 2.60 | 0.91 | 3.38 | 1.41 | 0.38 | 1.93 | 38.4 | 16.5 | 58.9 | 6.4 | 2.4 | 11.9 |
| 40—60 | 1.94 | 0.74 | 3.31 | 1.00 | 0.37 | 1.75 | 48.1 | 19.7 | 108.9 | 3.6 | 2.4 | 6.6 |

The salt content here decreases and the water content increases with depth, resulting in a marked decrease of the salt/water ratio, a fact indicating the upward movement of the salts.

(2) *Salicornion fruticosae* Br.—Bl. 1933

The associations of this alliance occupy the largest part of the salt marshes investigated. They are regularly arranged in zones, centering around the marsh in the following order: (a) *Tamaricetum meyeri mediterraneum*, (b) *Arthrocnemum glaucum* —

*Sphenopus divaricatus* assoc., (c) *Salicornia fruticosa — Halimione portulacoides* asso

(a) The *Tamaricetum meyeri mediterraneum* Zoh. et Orsh. This occupies the bank of the Na'aman and Kishon rivers. In the Na'aman salt marsh it occupies the edge of small lagoons of open water in late summer. Five records were made in this associa tion and the following plants were listed:

Characteristic species and/or differentials of association:

| | |
|---|---|
| *Tamarix meyeri* | 100 |

Characteristic species of class:

| | | | |
|---|---|---|---|
| *Arthrocnemum glaucum* | 100 | *Salicornia fruticosa* | 40 |
| *Halimione portulacoides* | 100 | *Salicornia herbacea* | 20 |
| *Juncus maritimus* | 60 | *Suaeda splendens* | 20 |

(b) Assoc. of *Arthrocnemum glaucum—Sphenopus divaricatus* Br.—Bl. 1933. This occu pies a great part of the Kishon salt marshes as well as considerable areas in the Naaman salt marshes. Two varieties were distinguished, one with almost no annuals, the othe with relatively numerous ones. In the 17 records made the following plants were listed

Characteristic species and/or differentials of association:

| | | | |
|---|---|---|---|
| *Arthrocnemum glaucum* | 100 | *Halopeplis amplexicaulis* | 6 |
| *Sphenopus divaricatus* | 47 | | |

Characteristic species of class:

| | | | |
|---|---|---|---|
| *Hordeum marinum* | 65 | *Statice limonium* | 29 |
| *Plantago coronopus* | 59 | *Cressa cretica* | 23 |
| *Pholiurus incurvus* | 53 | *Polypogon maritimus* | 23 |
| *Obione portulacoides* | 41 | *Aeluropus litoralis* | 15 |
| *Salicornia radicans* | 35 | *Salicornia herbacea* | 12 |
| *Spergularia* sp. | 35 | *Juncus maritimus* | 6 |
| *Salicornia fruticosa* | 29 | *Plantago crassifolia* | 6 |
| *Pholiurus filiformis* | 29 | | |

Accidentals:

| | | | |
|---|---|---|---|
| *Anagallis coerulea* | 18 | *Centaurium pulchellum* | 6 |
| *Lolium rigidum* | 12 | *Iris sisyrinchium* | 6 |
| *Plantago lagopus* | 6 | *Asteriscus aquaticus* | 6 |
| *Beta vulgaris* | 6 | | |

Table III represents the results of the examination of the soil samples taken in 7 stands of this association. It shows that water content increases with the depth and, except for the upper 20 cm layer, there is no significant difference in the salt content.

TABLE III

*Soluble salt and water content in the soil of* 7 Arthrocnemum glaucum *stands in per cent of dry weight*

| *Depth in cm* | *Total soluble salts* | | | *Cl'* | | | *Water content* | | | (*Sol. salts/water cont.*) × 100 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* |
| 0—20 | 2.56 | 0.41 | 4.61 | 1.13 | 0.11 | 2.01 | 13.5 | 6.3 | 30.7 | 17.7 | 4.3 | 42.0 |
| 20—40 | 1.84 | 0.66 | 3.22 | 0.96 | 0.32 | 1.78 | 23.2 | 13.0 | 41.7 | 8.1 | 3.6 | 10.9 |
| 40—60 | 2.07 | 0.45 | 3.61 | 0.97 | 0.20 | 1.46 | 31.9 | 13.1 | 43.1 | 6.8 | 1.5 | 12.2 |

(c) Assoc. of *Salicornia fruticosa—Halimione portulacoides* Zoh. et Orsh. This forms the outermost zone of the complex examined. Here the salt and water content are much smaller than in the former zones. Table IV represents the data of the soil samples taken in 5 stands.

TABLE IV

*Soluble salt and water content in the soil of* 5 Salicornia fruticosa — Halimione portulacoides *stands in per cent of dry weight*

| Depth in cm | Total soluble salts | | | $Cl'$ | | | Water content | | | (sol. salts/water cont.) × 100 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | aver. | min. | max. | aver. | min. | max. | aver. | min. | max. | aver. | min. | max. |
| 0—20 | 1.18 | 0.71 | 1.74 | 0.58 | 0.35 | 0.88 | 18.2 | 11.9 | 22.4 | 6.4 | 4.0 | 7.8 |
| 20—40 | 1.43 | 1.03 | 1.95 | 0.75 | 0.50 | 1.03 | 26.2 | 28.1 | 30.9 | 6.3 | 4.2 | 5.6 |
| 40—60 | 1.12 | 0.52 | 1.64 | 0.56 | 0.24 | 0.87 | 23.2 | 17.7 | 31.6 | 6.2 | 2.2 | 4.9 |

The leading plants of this association show a wide range as to salt and water content of the soil. 7 records were made and the following plants listed:

Characteristic species and/or differentials of association:

| | | | |
|---|---|---|---|
| *Salicornia fruticosa* | 100 | *Halimione portulacoides* | 100 |

Characteristic species of class:

| | | | |
|---|---|---|---|
| *Statice limonium* | 86 | *Salicornia herbacea* | 29 |
| *Cressa cretica* | 57 | *Phragmites communis* | 29 |
| *Hordeum marinum* | 43 | *Pholiurus filiformis* | 14 |
| *Pholiurus incurvus* | 43 | *Suaeda splendens* | 14 |
| *Arthrocnemum glaucum* | 29 | | |

Accidentals:

| | | | |
|---|---|---|---|
| *Plantago coronopus* | 14 | *Medicago ciliaris* | 14 |
| *Junctus acutus* | 14 | | |

(3) *Junceto—Phragmition* Zoh. et Orsh. 1949

The associations of this alliance are confined to banks of small water bodies running in the salt marsh and they form a zonation complex of their own. The water content of the soil often exceeds field capacity, while the salt content is moderate. The following associations are arranged according to their moisture requirements:

(a) *Phragmitetum communis salinum*, (b) *Juncetum maritimi*, (c) *Inuletum crithmoidis.*

(a) The *Phragmitetum communis salinum* Zoh. et Orsh. 1949. *Phragmites communis* is the leading plant in the non-halophytic *Scirpeto—Phragmitetum communis* of the *Phragmitetea* class. It also occurs as leading plant in the water bodies of salty or brackish water. In the latter habitat it is closely associated with typical halophytes. These facts justify the establishment of a separate association included in the halophytic *Salicornietea* class (See also Zohary and Orshansky 1953). Only two records were made in this association, containing the following plants:

Characteristic species and/or differentials of association:

*Phragmites communis*

Characteristic species of class:

*Arthrocnemum glaucum*
*Atriplex portulacoides*
*Statice limonium*
*Salicornia radicans*
*Pholiurus incurvus*
*Plantago crassifolia*

Accidentals:

*Cyperus distachyus*
*Typha angustata*

(b) The *Juncetum maritimi* Zoh. 1954. This forms a zone next to the *Phragmitetum* a the banks of water bodies within the salt marshes. In the Na'aman salt marshes it occu pies a considerable area with scattered small water bodies drying up in late summer Here the zone of *Phragmitetum* is sometimes absent because the soil becomes too dr in summer, although it is wet enough for the two other associations of the *Juncet Phragmition* alliance. Table V shows the results of soil samples taken in 4 stands. So moisture was found to be high even in the upper layers.

TABLE V

*Soluble salt and water content in the soil of* 4 Juncetum maritimi *stands in per cent of dry weight*

| *Depth in cm* | *Total soluble salts* | | | *Cl'* | | | *Water content* | | | *(Sol. salts/water cont.)* × 10 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* | *aver.* | *min.* | *max.* |
| 0—20 | 3.88 | 2.08 | 5.86 | 1.86 | 0.95 | 2.90 | 76.2 | 43.5 | 127.7 | 5.6 | 4.8 | 7.3 |
| 20—40 | 1.40 | 0.82 | 2.30 | 0.67 | 0.40 | 1.09 | 54.0 | 36.2 | 60.7 | 3.0 | 2.2 | 3.8 |
| 40—60 | 1.50 | 0.43 | 1.71 | 0.46 | 0.39 | 1.28 | 49.4 | 33.6 | 84.0 | 2.9 | 1.3 | 4.1 |

Eight records were made in this association and listed as follows:

Characteristic species and/or differentials of association:

| | | | |
|---|---|---|---|
| *Juncus maritimus* | 100 | *Agropyrum elongatum* | |

Characteristic species of class:

| | | | |
|---|---|---|---|
| *Arthrocnemum glaucum* | 88 | *Hordeum marinum* | 13 |
| *Statice limonium* | 88 | *Spergularia* sp. | 13 |
| *Halimione portulacoides* | 75 | *Pholiurus incurvus* | 13 |
| *Phragmites communis* | 50 | *Plantago crassifolia* | 13 |
| *Salicornia radicans* | 38 | *Cressa cretica* | 13 |
| *Salicornia fruticosa* | 38 | *Aeluropus litoralis* | 13 |
| *Inula crithmoides* | 25 | | |

Accidentals:

| | | | |
|---|---|---|---|
| *Juncus acutus* | 13 | *Agropyrum lanceolatum* | 13 |
| *Carex* sp. | 13 | | |

(c) The *Inuletum crythmoidis* Zoh. 1954. This association is very close in its ecology and composition to the *Juncetum maritimi* and forms an outer zone to it. As seen from Table VI, its habitat is slightly more dry and less saline, especially in the upper layers of the soil.

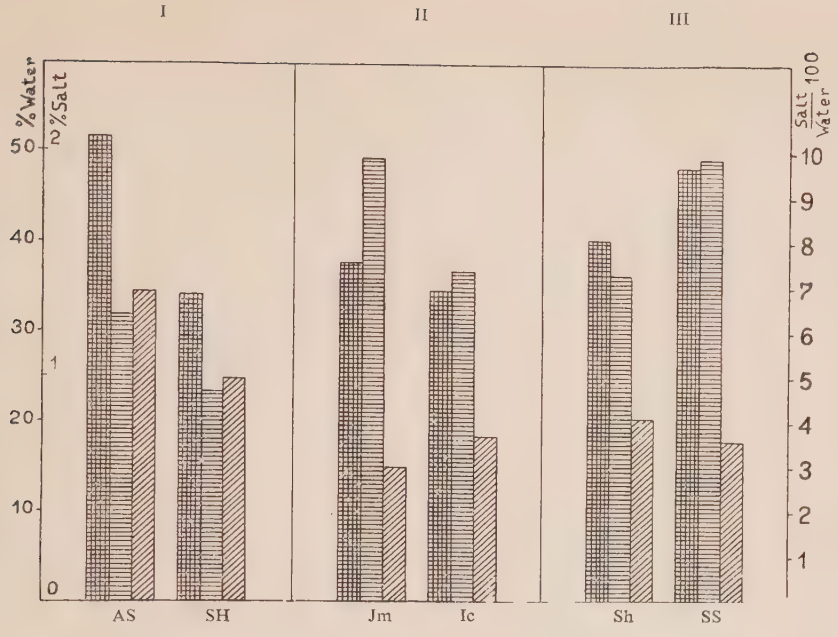


Plate 1

Graphic representation of salt and water relations, at 40—60 cm depth, in the soils of the following alliances and associations:

I = *Salicornion fruticosae* alliance
AS = *Arthrocnemum glaucum — Sphenopus divaricatus* association
SH = *Salicornia fruticosa — Halimione portulacoides* association

II = *Junceto-Phragmition* alliance
Jm = *Juncetum maritimi* association
Ic = *Inuletum crithmoidis* association

III = *Thero-Salicornion* alliance
Sh = *Salicornietum herbaceae* association
SS = *Salsola soda — Suaeda splendens* association

For each association the left column represents total soluble salts, the middle column the water content, and the right column the ratio (salts content / water content) x 100.

Photo 1. Alliance of *Salicornion fruticosae* in the Kishon marshes near Haifa

TABLE VI

*Soluble salt and water content in the soil of* 3 Inuletum crithmoidis *stands in per cent of dry weight*

| *Depth in cm* | *Total soluble salts* | *Cl'* | *Water content* | *(Sol. salts/water cont.) ×100* | | |
|---|---|---|---|---|---|---|
| | *aver.* | *aver.* | *aver.* | *aver.* | *min.* | *max.* |
| 0—20 | 0.87 | 0.43 | 15.3 | 5.7 | 5.3 | 6.1 |
| 20—40 | 1.08 | 0.54 | 25.7 | 4.2 | 3.7 | 4.7 |
| 40—60 | 1.39 | 0.66 | 36.9 | 3.7 | 3.4 | 4.0 |

The following plants were listed in the three records made in this association:

Characteristic species and/or differentials of association:

| | |
|---|---|
| *Inula crithmoides* | 100 |

Characteristic species of class:

| | | | |
|---|---|---|---|
| *Halimione portulacoides* | 100 | *Plantago crassifolia* | 67 |
| *Statice limonium* | 100 | *Salicornia herbacea* | 33 |
| *Pholiurus filiformis* | 100 | *Cressa cretica* | 33 |
| *Salicornia fruticosa* | 67 | *Polypogon maritimus* | 33 |

SUMMARY

1. In the vegetation of the coastal salt marshes of Israel eight associations of three well established halophytic alliances were found, and their salt and water relations examined.

2. The associations of the *Salicornion fruticosae* alliance occupy the largest part of the salt marshes and form around it the following zonal complex: (a) *Tamaricetum Meyeri mediterraneum* (b) *Arthrocnemum glaucum — Sphenopus divaricatus* association (c) *Salicornia fruticosa — Halimione portulacoides* association.

3. The associations of the *Junceto—Phragmition* alliance are confined to the banks of small water bodies and form there the following zonal complex: (a) *Phragmitetum communis salinum* (b) *Juncetum maritimi* (c) *Inuletum crithmoides.*

4. In the zonal complexes of the *Salicornion fruticosae* and the *Junceto—Phragmition* alliances, the salt and water content decrease towards the periphery.

5. The *Thero—Salicornion* alliance is represented by the two pioneer associations, the *Salicornietum herbaceae* and the *Salsola Soda—Suaeda splendens* association, occupying small areas in the lower parts of the salt marshes which dry out only in late summer or in areas under somewhat segetal and ruderal conditions.

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# THE EFFECT OF LIGHT AND TEMPERATURE ON THE GERMINATION OF *AMARANTHUS BLITOIDES* SEEDS

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An extensive study on the effect of light, temperature and other factors on the germination of lettuce seeds is being carried out in this laboratory. It was desirable to compare the effect of these factors on the germination of other light-sensitive seeds.

As preliminary work showed that the seeds of *Amaranthus blitoides* are highly sensitive to different combinations of light and temperature, these seeds were chosen for experiments to be reported here. *Amaranthus blitoides* is a ruderal summer annual. In the vicinity of Jerusalem its first seedlings emerge at the beginning of April, the seeds ripen during the late summer and autumn (September—November).

## MATERIAL AND METHODS

The seeds used were collected in Jerusalem on November 23rd, 1952, from a single plant. They were stored in tightly stoppered glass jars at room temperature, in the dark.

Germination tests were carried out in Petri dishes on a double layer of filter paper moistened with 7 ml tap water. Every experiment was carried out with at least two replicates on the same date and usually repeated at different dates. At first 100 seeds were used per dish, later the number was decreased to 50 and even 25. In the latter cases, however, more replicates were used.

The Petri dishes were kept in light-tight boxes in incubators of various temperatures. Light stimuli of 125 F.C. were given either directly from an incandescent light bulb or the light from the same source and of the same intensity was passed through various filters. The filters used were: Corning glass filters No. 245 (red) and No. 430 (blue) — the latter only for seedling counts, and Kodak Wratten gelatin filters No. 45 (blue) and 88 A (infrared). An infrared absorbing solution was also used. The transmission spectrum of the filters, as well as the composition of the solution, have been reported by Evenari and Neumann (1953).

## EXPERIMENTAL RESULTS

### *A. Stimulating irradiations*

Germination tests were carried out at various temperatures using various light treatments, these being: continuous darkness, continuous light and darkness interrupted by five minutes of white light, 48 hours after sowing — "short illumination". The results are given in Table I.

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TABLE I

*Germination percentages of* Amaranthus blitoides *seeds under various light and temperature treatments*

| *Temperature (°C)* | *Continuous illumination* | | *Short illumination* | | *Continuous darkness* | |
|---|---|---|---|---|---|---|
| | *% germ.* | *s.d.* | *% germ.* | *s.d.* | *% germ.* | *s.d.* |
| Up to 24 | 0 | — | 0 | — | 0 | — |
| 26 | 1 | 1 | 3 | 2 | 0 | — |
| 28 | 0 | — | 9 | 4 | 0 | — |
| 29—30 | 3 | 1 | — | — | 1 | — |
| 30—31 | 49 | 13 | 97 | 1 | 23 | 6 |
| 30—33 | 96 | 4 | 100 | 0 | 32 | 12 |
| 35—37 | 94 | 7 | 99 | 5 | 58 | 13 |
| 40 | 76 | 4 | 88 | 9 | 10 | 5 |
| 42—44 | 80 | 10 | 85 | 11 | 0 | — |

Table I shows that the optimal temperature for germination was rather high. Small changes in temperature induced marked differences in germination. Seeds which failed to germinate at 43—46° C could be induced to germinate by transfer to 30° C. This was not the case for seeds failing to germinate at 50° C.

Light invariably stimulated germination, short illumination being more effective than a continuous one.

In order to find the most suitable time for the application of the light, short illumination was given at various intervals after sowing, as summarized in Table II.

From Table II it is apparent that sensitivity to light increases with the time interval between sowing and the application of the light stimulus. As a maximal stimulation was obtained after 48 hours, the light stimulus was usually applied at this time. After 48 hours, dark germination was apparently completed.

The effect of duration of the short illumination was studied using white light. The results are presented in Table III.

TABLE II

*The effect of the time interval between sowing and application of short illumination* (5 *min. at* 125 *F.C.*) *on germination at* 30°*C*

| *Length of interval (hrs.)* | *% germ.* | *s.d.* |
|---|---|---|
| 0 | 6 | — |
| 6 | 8 | 7 |
| 8 | 12 | 6 |
| 10 | 15 | 1 |
| 16 | 19 | 1 |
| 24 | 38 | 4 |
| 28 | 42 | 6 |
| 38 | 73 | 3 |
| 48 | 87 | 1 |

TABLE III

*Effect of duration of the short illumination* (*white light*, 125 *F.C.*) *on germination of* Amaranthus blitoides *seeds at* 30°*C; stimulus applied* 48 *hrs. after sowing*

| *Duration of stimulus in seconds* | *% germination* |
|---|---|
| 0 | 25 |
| 1 | 31 |
| 2.5 | 23 |
| 5 | 63 |
| 15 | 80 |
| 30 | 83 |
| 45 | 92 |
| 60 | 91 |
| 90 | 85 |
| 600 | 87 |

It will be seen that 15 seconds of white light of 125 F.C. intensity greatly stimulate germination. Prolongation of the stimulus above 45 seconds does not increase the effect.

Similar experiments with red light showed that 15 seconds gave maximal stimulation of germination.

### *B. Inhibiting irradiations*

According to Resuehr (1939) the inhibiting regions of the spectrum are the infrared (700—800 m μ) and the blue (440—450 m μ and 475—490 m μ). Therefore, the effect of infrared, blue and infrared-free blue light on germination was determined.

Preliminary experiments showed that those seeds which are capable of germination in the dark, are not inhibited by the above radiations. It was also found that the inhibiting effect of these radiations on light-stimulated seeds decreases with the lengthening of the interval between stimulating and inhibiting treatments. Similar results were obtained by Evenari and Neumann (1953) for lettuce seeds. In subsequent experiments the inhibiting light was, therefore, supplied immediately after stimulating one, 48 and 96 hours after sowing.

The effect of infrared radiation on seeds prestimulated by 15 seconds of red light is presented in Table IV.

As is seen from Table IV, 10 minutes of infrared light nullified the stimulating effect caused by 15 seconds of red light. Whenever red light was given again following infrared, the inhibitory influence of the latter was completely overcome (see also Borthwick et al. 1952).

The effect of blue light was also tested. As the blue filter used also transmitted infrared radiation, the latter was filtered out using an infrared absorbing solution. This treatment was compared with the effect of the original blue filter (Table V).

TABLE IV

*Effect of duration of infrared light on* Amaranthus blitoides *seeds prestimulated by* 15 *seconds of red light; seeds kept at* 30°*C, stimulus applied* 48 *hrs. after sowing*

| *Duration of infrared irradiation* | *% germination* |
|---|---|
| 0 sec. | 100 |
| 15 sec. | 100 |
| 30 sec. | 100 |
| 60 sec. | 64 |
| 5 min. | 18 |
| 10 min. | 8 |
| 20 min. | 8 |

TABLE V

*Effect of* 10 *minutes of infrared, blue and infrared-free blue radiation on the germination of* Amaranthus blitoides *seeds prestimulated by* 15 *seconds of red light at* 30°*C*

| *Kind of stimulus* | *% germination* | |
|---|---|---|
| | *Time of application of light after sowing* | |
| | 48 *hrs.* | 96 *hrs.* |
| Red | 100 | 100 |
| Infrared | 8 | 38 |
| Blue | 14 | 61 |
| Infrared-free blue | 86 | 98 |

It is evident from Table V that "short" pure blue illumination does not affect the germination of *Amaranthus blitoides* seeds. The inhibitory effect resulting from the use of the blue filter is due only to the infrared radiation transmitted by it. In the other experiments it was shown that prolongation of the pure blue irradiation up to 20 minutes did not change its effect.

When determining dark germination, the first seedlings appear 16 hours after sowing. By 24 hours the dark germination is almost completed and only sporadic seedlings appear up to 48 hours. After this time no more seeds germinate unless stimulated by light. The problem arose whether dark germination can be inhibited by infrared short illumination. From Table II it is evident that stimulating short illumination has little effect during the early hours of germination.

The experiments on dark germination were carried out at 37° C, as at this temperature dark germination is rather high (Table I). The effect of 10 minutes of infrared radiation given during the early stages of germination is presented in Table VI. The same table also presents the effect of 15 seconds of red irradiation and red followed by 10 minute of infrared.

TABLE VI

*Effects of various radiations on the germination of* Amaranthus blitoides seeds at 37° *C; the illumination was applied during the early hours of germination*

| *Kind of treatment* / *Time of application (hrs. after sowing)* | 0 | 0.5 | 1 | 2 | 3 | 7 | 11 | 16 | 24 | 48 |
|---|---|---|---|---|---|---|---|---|---|---|
| Continuous darkness | 58 | | | | | | | | | |
| 10 minutes infrared | 46 | 42 | 56 | 52 | 40 | 54 | 54 | 54 | 58 | — |
| 15 seconds red | — | — | — | — | 56 | — | — | — | 94 | 98 |
| 15 seconds red followed by 10 minutes infrared | — | — | — | — | 58 | — | — | — | 60 | 62 |

It is clear from Table VI that infrared illumination has no effect on dark germination at 37° C. It does, however, inhibit the germination of the light-stimulated seeds even at this high temperature.

## DISCUSSION

Seeds of *Amaranthus blitoides* were shown to behave very similarly to tobacco seeds (Kincaid 1935) and lettuce seeds (Evenari 1952) in their light sensitivity. They differed from lettuce seeds in that the maximal light stimulation in these is 2 hours after imbibition, while in *Amaranthus* it is 48 hours after imbibition.

The seeds were also shown to have a high temperature requirement for germination. At all temperatures continuous illumination was less effective than short illumination in stimulating germination. Similar results have been obtained for other seeds by Evenari (1952) and Soriano (1953).

Resuehr showed that the stimulating and inhibiting spectral regions are the same for most kinds of light-sensitive seeds (light- and dark-germinators). There is some controversy regarding the effect of blue light. As already cited, Resuehr and others have found inhibition at 440—450 mμ and 475—490 mμ. The blue filter used in our experiments transmitted the whole region between 430—540 mμ, with a peak at 480 mμ, i.e. it contains Resuehr's inhibiting blue regions, but it also transmits some of the inhibiting red regions above 700 mμ. Irradiations through this filter caused an inhibition slightly lower than that caused by the infrared filter, but the elimination of the infrared region from the blue filter caused the loss of its inhibitory action (Table V).

From the data presented in Table V it seems that sensitivity towards inhibiting irradiations decreases with the progress of germination.

Evenari and Stein (1953 a) tried to explain the infrared versus red effect on germination by supposing that red light converts a substance A into another substance B, B being essential for germination. Infrared radiation is supposed to reverse the above reaction and thus inhibit germination. But if infrared really destroys substance B which is essential for germination, it should inhibit dark germination as well. The fact that it does not (Table VI) suggests the existence of other alternative mechanisms for dark germination (See also Evenari et al. 1953 b).

SUMMARY

The effect of light and temperature on the germination of *Amaranthus blitoides* was investigated.

It was found that the suitable temperature for the germination of these seeds in the laboratory was 30—37° C. White and red light stimulated germination at all temperatures. Short light stimulation was found to be more effective than continuous illumination. Infrared radiation did not affect the dark germination but nullified the effect of the red light. Blue light was found to have no effect on germination.

ACKNOWLEDGMENT

I am indebted to Prof. M. Evenari for initiating this research and for his interest and advice throughout the work.

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# NOTES ON THE GERMINATION OF *ATRIPLEX ROSEA*

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Many species of *Atriplex* are known to bear dimorphic fruits. Becker (1912) showed that *Atriplex hortensis* has four kinds of flowers, each giving rise to fruits of different colour and shape. According to Koller (1954), *Atriplex dimorphostegia* carries dispersal units (or false fruits) differing greatly in size and shape, but no colour differences could be perceived in the seeds. Seeds from the two kinds of dispersal units differed greatly in their germination behaviour. Beadle (1952), working with five species of *Atriplex* from Australia, found in three of them black and brown seeds. He did not record any differences in the dispersal units, but stated that black and brown seeds differed greatly in their germination. While the germination of the black seeds, which initially germinate poorly, increases with time, the reverse is the case for the brown seeds.

*Atriplex rosea* L. is a ruderal summer annual. Its germination near Jerusalem begins in mid-winter and the seeds ripen during August—October.

The results to be reported here deal chiefly with the germination behaviour of the dimorphic seeds of *A. rosea* and the germination inhibiting properties of the fruit bracts.

## MATERIAL AND METHODS

Mature dispersal units (d.u.) were collected in Jerusalem on two separate occasions: in December 1952 and October 1953. Only seeds collected in 1952 were used for germination tests. The d.u. were stored in glass jars at room temperatures, in the dark.

The seeds were extracted from the dispersal unit by gentle grinding in a mortar. All seeds were then carefully examined under a magnifying glass, and divided into brown and black, as well as into intact seeds and those with testa slightly cracked. In case of greater damage, the seeds were discarded. Only large and medium seeds were used for germination tests. These were carried out in Petri dishes on a double layer of filter paper moistened with tap water. Twenty five of fifty seeds were used per dish, with at least two replicates for every date. For germination in the dark the Petri dishes were kept in light-tight boxes, and were either not opened till the end of the experiments, or opened every two days and the seedlings counted in blue light. Chloride was estimated either gravimetrically as silver chloride or volumetrically by Mohr's method (Kolthoff and Sandell 1943). For the Mohr titration the extracts were decolorized with charcoal.

## EXPERIMENTAL RESULTS AND DISCUSSION

### *Seed dimorphism*

The fruits are monospermous and enclosed between two bracts. The bracts are fused

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at their base, and together with the fruit form the dispersal unit (or "false fruit"). The pericarp is membranous, and adheres to the bracts so that it is usually fragmented when the seeds are extracted from the bracts.

There are two kinds of seeds on the same plant, light brown and black, only few being intermediate in colour, i.e. dark brown. The black seeds have a hard, thick testa which is easily peeled off. They are round and uniform in size and weight. The brown seeds are flattened and more variable in colour and size, their testa is thin and does not peel off. The average weight of fifty black seeds was 66 mg (s.d. 1.5), the weight of fifty brown seeds was 75 mg (s.d. 6). This difference was found to be significant ($P=0.01$).

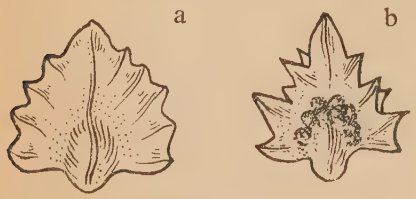



Figure 1
Dispersal units of *Atriplex rosea*; a. smooth, b. wrinkled.

Careful examination showed that the dispersal units could also be divided into two definite classes: smooth and wrinkled (Figure 1), Smooth d.u. always contained brown seeds, whereas the wrinkled ones contained only black seeds. No definite order could be perceived in the distribution of the different d.u. on the plant.

*Germination tests*

The germination ability of the seeds was tested at various intervals after harvesting. The results are presented in Table I.

TABLE I

*Germination percentages of intact seeds in light at different temperatures at various intervals after harvesting*

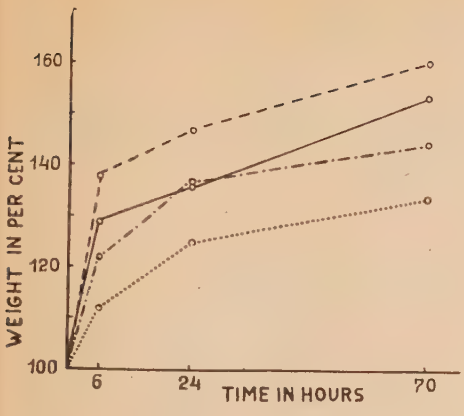
| | *Months after harvest* | 1 | 3 | 8 | 11 |
|---|---|---|---|---|---|
| | *Temperature (°C)* | | *% germination* | | |
| Brown seeds | 20 | 90 | — | 100 | — |
| | 24 | 92 | 96 | — | 95 |
| | 30 | 64 | — | 95 | 100 |
| Black seeds | 20 | 48 | — | 90 | — |
| | 24 | 24 | 54 | — | — |
| | 30 | 34 | — | 67 | 68 |

It appears that brown seeds have a higher germination capacity than black ones. The germination of the brown seeds does not change appreciably throughout the year; the germination percentage of the black seeds increases with time.

Beadle (1952), working with other species of *Atriplex*, attributes the differences in germination to the impermeability of the testa of the black seeds to water. It was of interest to see whether this applies to *Atriplex rosea* also.

Black seeds were divided into three lots according to the condition of their testa: (a) intact, (b) slightly cracked, (c) with testa peeled off. Brown seeds were divided into lots (a) and (b) only. Germination results are presented in Table II.

From Table II it is evident that germination of black seeds is greatly enhanced by slight cracks in the testa, although far from attaining the germination capacity of brown seeds. Removal of the testa does not increase this effect.




Imbibition experiments were carried out by weighing and the results are presented in Figure 2. There was no difference between lots (b) and (c) of the black seeds.

From these data it is evident that the testa of the black seeds is not completely impermeable to water but does retard imbibition. Black seeds, even when cracked, do not imbibe as much water as the intact brown seeds.

Figure 2
Inhibition of brown and black *Atriplex* seeds
Brown intact ———— Black intact .....
Brown cracked — — — — Black cracked ·—·—·

The differences in germination (Table II) and imbibition (Figure 2) of black and brown seeds cannot be attributed only to differences in testa permeability. Explanation of the different capacity for swelling should be looked for elsewhere; it might be worthwhile to investigate the storage materials of the two kinds of seeds.

Other differences are evident from the reaction of the seeds to light (Table III) and to the germination inhibitors contained in the bracts (Table V).

TABLE II

*The effect of condition of the testa on the germination percentages of brown and black seeds at 24°C in light*

| *Condition of testa* | *a Intact* | *b Slightly cracked* | *c Peeled off* |
|---|---|---|---|
| Brown seeds | 94 | 100 | — |
| Black seeds | 24 | 56 | 54 |

TABLE III

*Germination percentages in light and dark at 20°C*

| | *Light* | *Dark* |
|---|---|---|
| Brown seeds | 100 | 76 |
| Black seeds | 90 | 13 |

It is evident from Table III that light enhances germination of all seeds, but this is more pronounced in the black ones.

The ecological advantage of this varying behaviour is apparent: the germination of seeds derived from a single annual plant is spread over a number of years, a store of seeds being always ready to germinate even after several unfavourable seasons.

It is interesting to note that out of four species of annuals investigated by the author as to their germination physiology, three were heterocarpic or heterospermic (*Atriplex rosea*, *Amaranthus lividus* and *Hymenocarpus circinnatus* — unpublished). Zohary (1934) discussed these phenomena in their broader aspects.

*Germination inhibitor in the fruit bracts*

Germination of whole dispersal units was compared with that of the seeds and found to be lower, as is evident from Table IV.

This same effect was apparent when empty bracts or water extract of the bracts were added to the Petri dishes in which the seeds were germinated. The inhibitory effect can therefore be attributed to a germination inhibiting substance present in the bracts.

The chloride content of *A. rosea* bracts was therefore determined. The chloride content was found to be 3.6% of the air dry weight of the bracts. This must be considered a rather high value for a nonhalophyte plant.

When bract extracts were decolorized with charcoal they no longer inhibited germination (Table V) despite the fact that decolorization did not remove the chloride. Moreover, chloride solutions equimolar for $Cl^-$ to the bract extracts (M/50 $Cl^-$) did not inhibit germination. NaCl, KCl, $CaCl_2$ and $NH_4Cl$ were tested.

TABLE IV

*Germination % of dispersal units as compared with the seeds at 24°C in the light*

| *Dispersal units* | | *Seeds* | |
|---|---|---|---|
| Smooth | 16 | Brown | 92 |
| Wrinkled | 3 | Black | 34 |

TABLE V

*The effect of bract extract and decolorized bract extract on germination % at 24°C in the light*

| | *Bract extract* | *Decolorized extract* | *Water* |
|---|---|---|---|
| Brown seeds | 64 | 98 | 100 |
| Black seeds | 0 | 28 | 16 |

* The extract was prepared by extracting 10 g of bracts in distilled water for twenty-four hours, filtering the solution and washing the bracts, making up 500 ml of solution; decolorization was effected with charcoal.

It must, therefore, be concluded that the chloride content of the bracts does not cause germination inhibition. An inhibitor which is absorbed on charcoal is apparently present in the bracts.

## SUMNARY

*Atriplex rosea L.* was shown to bear two kinds of dispersal units, each containing different seeds.

The two types of seeds differ in colour, size, weight, shape and in the thickness of their testa.

The seeds differ also in their germination ability and in their reaction to light, temperature and germination inhibitors.

It was shown that differences in permeability of the seed coats to water cannot be the sole factor causing the above differences.

The fruit bracts were shown to contain a germination inhibitor. This inhibitor was not the chloride ion.

## ACKNOWLEDGMENT

I wish to express my thanks to Prof. M. Evenari for his encouragement and advice during this investigation.

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# GERMINATION REGULATING MECHANISMS IN SOME DESERT SEEDS I

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## REVIEW OF LITERATURE

The establishment and existence of a wild plant depends entirely upon the correspondence of its ecological demands to the conditions of its habitat, a correspondence which has to exist throughout all stages of its development. It follows that the course of evolution should eventually bring about a condition that will either scatter seed germination over extended periods, or restrict it to such a combination of factors (climatic and edaphic) as will ensure the maximum chances for the germinated seedling to complete successfully its various developmental stages "from seed to seed". This problem of existence has led to the evolution of germination regulating mechanisms (usually called "dormancy") in the seeds and fruits of wild plants (Crocker 1916, Toole 1936, Barton and Crocker 1948, Bibbey 1948, Porter 1949, Crocker and Barton 1953).

The problems of survival which confront wild plants as a whole are much more pronounced in the case of desert plants. The corrylex of ecological factors surrounding the desert plant is much more extreme than that surrounding most other plants. It is in the nature of deserts that a combination of factors favourable to growth usually exists only in specific and rather scattered habitats (often only where microclimatic and microedaphic conditions permit), during specific and relatively short seasons, and sometimes even only once in several years (Zohary 1944).

Much work has been done on problems of dormancy in the seeds of many species, and desert plants have had their share (Barton 1936; Went 1942, 1948, 1949; Went and Westergraad 1949; Soriano 1953).

Desert plants are of particular interest because of the peculiar ecological, physiological, and plant sociological problems involved in their survival. Quite apart from any purely scientific interest in the regulation of germination in desert plants there is special importance in testing the germination of those desert species which promise to be of economic value as industrial, medicinal, and pasture plants (Boyko 1949, D. Zohary 1952). This research was undertaken with the aim of contributing some knowledge in these respects regarding a few desert species from Israel.

The term "dormancy" has been variously defined and used by different workers, and to this day a great deal of controversy exists as regards this nomenclature. Even the broadest definition of a "dormant seed" as one which does not germinate "when ordinary requirements of moisture and temperature have been met" (Barton and Crocker 1948), leaves much to be desired, because, usually, "ordinary requirements" which

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are optimal for the germination of different species vary widely. It seems that the only real difference between "dormant" and "non-dormant" seeds is between the degree of specificity of conditions which the seeds require for germination. It is daily becoming more apparent that seeds of all species will exhibit no dormancy if placed in the exact replicate of the average conditions which exist in their habitat from the onset of seed maturation till the season of germination (provided, of course, that every operative factor has direct access to that part of the seed which is, or has to be, affected by it).

Once it is accepted that time is also a factor affecting germination, and that the action of some of the other factors is sometimes strongly correlated with this "time factor", it is quite easy to discard "dormancy" as a superfluous term. It appears, therefore, that the various mechanisms of dormancy are no more than ways and means which cooperate to ensure the survival of the species by regulating germination, and either confining it to the suitable habitat and season, or scattering it over extended periods of time.

With the above considerations in mind, the various germination regulating factors may be classified as follows: (i) water relationships between the embryo and the medium, before and during the actual process of germination; (ii) relative concentration of the respiratory gases (carbon dioxide and oxygen) in the medium, and length of time seeds are exposed to them during germination (and, to some extent, prior to it); (iii) temperature of the medium (constant, daily alternating, or seasonally alternating), before and during germination; (iv) mechanical factors in the coats enclosing the embryo, regulating moisture exchange, gas exchange, or exchange of solutes between embryo and medium, or offering mechanical resistance to the expansion of the growing embryo; (v) exogenous chemical effects of growth regulators (mainly inhibitors) diffusing from plant tissues or organs which accompany the embryo upon its dispersal, or which are discarded from the mother-plant or neighbouring plants (kin or alien) in the vicinity of the seed; (vi) intensity, duration, and spectral composition of illumination prior to, and during germination; (vii) age of seed after harvest.

Very strong interactions often exist between some of the above mentioned factors. Thus the moisture relationships between embryo and medium are often greatly influenced by the permeability to water of the various coats enclosing the embryo. The same applies to gas regulating membranes which would permit different concentrations of gas to exist within and without the seed. On the other hand, the degree of permeability of these coats is liable to change under certain conditions of temperature, moisture, etc. The effects of the respiratory gases are often modified by the temperature. A clear-cut correlation often exists between moisture relationships prior to germination, and the action of chemical inhibitors, as the quantity of the latter may change under the influence of rain, dew, capillary movement of the soil moisture, etc. The response of germination to illumination depends not only on intensity, duration, and quality, but also on the temperature during germination, and on conditions of moisture and illumination prior to germination. The age of the seed from harvest, besides affecting its viability, sometimes has a marked influence on the temperature requirements for germination, on the light response, and on the degree of impermeability of the various coats. Lastly, several cases are known where the response to light is modified by the presence of various structures enclosing the embryo, and by the relative concentration of the respiratory gases.

It has been shown that, though germination itself is a function of the embryo, the structures enclosing the embryo may exert a profound influence in regulating its germination. These structures, regulating, as they do, exchange of materials between embryo and medium, opposing expansion of the embryo, influencing its light-requirements, or containing germination-inhibitors, may be made up of morphologically different plant organs. The latter may vary from nucellar membranes and endosperm, to the receptacle and neighbouring bracts and sterile florets.

As long as these structures accompany the embryo from the time of seed-dispersal to the moment of germination, they are important to the process of germination. Consequently, so long as the embryo is dispersed in nature with any kind of tissue adhering to it, which may or may not influence its germination, this tissue should not be ignored, even though it is not a part of the seed proper.

With this consideration in mind, the testing of germination should always start with the dispersal unit, and not the isolated seed. Great care should be taken to speak of the germination of the seed solely in those cases where the dispersal unit consists of the seed only, in the strict botanical sense.

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## GERMINATION REGULATING MECHANISMS IN SOME DESERT SEEDS II

### II. *ZYGOPHYLLUM DUMOSUM* BOISS.

*Zygophyllum dumosum* is a fleshy-leaved dwarf-shrub of the deserts of Southern Israel, belonging to the Saharo-Sindian phyto-geographical element. Along with *Haloxylon articulatum* it inhabits saline gravel deserts (hammadas), the soils of which contain up to 1.66 per cent salt (Evenari and Orshansky 1948). It is also the main component of the *Zygophylletum dumosi* community which inhabits the rocky ground of Senonian and Eocenian origin in the Saharo-Sindian desert of Israel. In these habitats, with less than 100 mm annual rainfall, growth of plants is made possible by accumulation of rain water

and its protection from evaporation by the rocky layer (Zohary 1944). Osmotic pressure of the sap is relatively low, and the root system is not extensive (Evenari 1940, Tadmor 1954). The main adaptation of the plant to desert conditions is by leaf abscission at the end of the growing season (Evenari 1940).

The five-valved fruit dehisces, upon drying, into five one- to two-seeded wing-shaped dispersal units of yellowish-brown colour. Although the pocket containing the seed is slightly open, the seed remains attached, being enclosed by the valve.

## MATERIALS AND METHODS

Dispersal units were collected from the plant and from the soil underneath in July 1952, and once again in July 1953, about sixty miles south of Beersheba, and stored in stoppered glass jars.

Germination was carried out in Petri dishes (9 cm$\phi$), on a single or double layer of filter paper moistened with tap water. Counts were made every two days, germinated seedlings taken out, and water added wherever necessary.

Illuminated incubators at 15, 20, 26, 28 and 30° C were used. Alternating temperatures were obtained by transferring the dishes from the lower-temperature incubator to the higher-temperature incubator for eight hours daily. Most experiments were run parallel in light (incandescent or fluorescent) and in dark (by placing the dishes in light-tight tins).

All chemicals used were of analytical grade, and distilled water was used in all solutions. Ash determinations were made by incineration at 400—450° C in a muffle furnace. Chloride determinations were made according to the Mohr titration, or gravimetrically by precipitation with $AgNO_3$. Osmotic pressure was determined cryoscopically (Walter 1931).

## RESULTS AND DISCUSSION

### *Germination in the dispersal units*

Lots of fifty to sixty dispersal units sown in 3 ml of water in various light/temperature combinations (between 16 and 28° C) failed to germinate within ten days, although the seeds had swelled visibly. Seeds extracted from the valves and germinated in their presence (fifty per lot) also failed to germinate, although naked seeds germinated well. These results indicated the presence of a water-soluble inhibitor in the fruit coat.

### *Germination of naked seeds*

The germination of naked seeds (1952 crop) was tested several times at different temperatures in light and in the dark. Germination commenced within forty eight hours after moistening, and was practically over within ten days. Final germination percentages at various constant and daily alternating temperatures are presented in Table I.

These results indicate that seeds of *Zygophyllum dumosum* germinate well and rapidly at all ages and over a wide temperature range (between 15 and 26° C), but that the lower temperatures are somewhat more favourable. Germination at daily alternating temperatures was intermediate between that of the higher and that of the lower constant

TABLE I

*Germination percentages (on 10th day) of seeds of* Zygophyllum dumosum *under various light/temperature conditions, and at different ages after harvest (at least 50 seeds per sample)*

| *Germination conditions* | *Age of seed from harvest (in months)* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.7 | 1.8 | 2.1 | 3.0 | 3.2 | 9.2 | 9.9 | 12.4 | 15.0 |
| 15°L | — | — | — | — | 77 | 76 | — | — | — |
| 15°D | — | — | — | — | 80 | 80 | — | — | — |
| 20°L | 58 | 82 | 66 | 74 | — | 84 | 92 | 92 | 86 |
| 20°D | 71 | 70 | 86 | 80 | — | 82 | 94 | 84 | 86 |
| 26°L | 51 | 60 | 56 | 62 | — | 72 | 64 | 42 | 68 |
| 26°D | 61 | 70 | 74 | 74 | — | 82 | 72 | 72 | 68 |
| 28°L | 34 | 70 | 30 | — | — | — | — | — | — |
| 28°D | 51 | 40 | 20 | — | — | — | — | — | — |
| 30°L | — | — | — | 12 | — | — | — | 18 | 12 |
| 30°D | — | — | — | 10 | — | — | — | 10 | 16 |
| 20°L—26°L | — | — | — | — | — | — | — | 82 | — |
| 20°D—26°D | — | — | — | — | — | — | — | 78 | — |
| 20°D—30°L | — | — | — | 50 | — | — | — | — | 68 |

temperatures. Germination may, therefore, be considered as relatively insensitive to temperature within that range. Light also seems to exert little effect on the germination percentage, but it apparently has a slightly retarding effect on seedling growth. This effect, and also the great variability in germination percentages in light, could, however, be a result of the more variable conditions in the dishes when in the light.

### *Inhibitors in the fruit coat*

The properties of the inhibitor which diffuses out of the valves were investigated. In a preliminary test, lettuce seeds of the varieties Progress and Grand Rapids were germinated in water, in the presence of a few empty *Zygophyllum* valves per dish, at 26° C, in the dark. Germination of seeds of Grand Rapids was completely inhibited; that of Progress seeds only partly so. Lettuce seedling growth in presence of the valves was greatly retarded. In a quantitative repetition of this experiment 2.5 g ground-up valves were extracted in 100 ml distilled water at 26° C during sixteen hours. Lettuce seeds of the two varieties were sown in this extract at full and half strength respectively, at 20 and 26° C, in the dark. Germination percentages after forty eight hours are presented in Table II.

TABLE II

*Dark germination of lettuce seeds after 48 hrs. in an extract of 2.5 g ground-up air dried fruit valves of* Zygophyllum dumosum *in 100 ml water*

| | *Grand Rapids* | | | | *Progress* | | | |
|---|---|---|---|---|---|---|---|---|
| | 20°C | | 26°C | | 20°C | | 26°C | |
| | % | *S.D.* | % | *S.D.* | % | *S.D.* | % | *S.D.* |
| Water control | 76.0 | 11.3 | 67.5 | 4.9 | 72.0 | 5.7 | 77.0 | 7.1 |
| Extract (full strength) | 7.5 | 0.7 | 0.5 | 0.7 | 29.5 | 11.6 | 17.5 | 3.5 |
| Extract (half strength) | 84.5 | 2.1 | 27.5 | 3.5 | 74.5 | 6.4 | 58.5 | 0.7 |

The inhibiting properties of the extract were not lost or diminished on boiling or centrifugation.

TABLE III

*Inorganic composition of air dried fruit valves of* Zygophyllum dumosum (*in per cent of dry weight*)

| | | |
|---|---|---|
| *A. Results of analysis* | | |
| | Ca | 6.00 |
| | K | 0.86 |
| | Na | 3.34 |
| | $NH_4$ | 0.00 |
| | Cl | 12.20 |
| | $SO_4$ | 3.44 |
| | $PO_4$ | 0.13 |
| | $CO_3$ | 0.00 |
| | Sesquioxides | 0.50 |
| | $SiO_2$ | 3.40 |
| | Total | 29.87 |
| | Ash | 30.33 |
| *B. Assumed composition* | | |
| | $CaSO_4$ | 4.85 |
| | $CaCl_2$ | 1.64 |
| | KCl | 1.64 |
| | NaCl | 4.83 |
| | $x(Na_2O) \cdot y(SiO_2)$ | 5.34 |
| | $R_2O$; $P_2O_5$ | 0.63 |

These experiments demonstrate clearly the presence of water-soluble, thermostable germination inhibitor(s) in the fruit coat of *Zygophyllum dumosum*. Although this inhibitor appears to be non-specific, the two varieties of lettuce exhibited differing degrees of susceptibility to it. This property is also known in inhibitors from other sources (Evenari 1949).

The hygroscopic properties of the fruit coat and its salty taste suggested that the inhibitor might be inorganic (Duym et al. 1947). An inorganic analysis of the ground-up valve coats was carried out in the Government Analytical Laboratories, and the results are presented in Table III.

The results of this analysis show that chloride, which makes up 12.2 per cent of the dry matter of the valves and 40.2 per cent of the total ash, is the most abundant ion. Two more chloride determinations by the Mohr titration method on extracts from ground-up valves which had been dried in a desiccator gave even slightly higher values (13.3 and 14.0 per cent of the dry matter respectively).

On the basis of these results it was decided to test the effect of NaCl solutions on the germination of *Zygophyllum* seeds. Lots of twenty five seeds each were germinated in various concentrations of NaCl, and transferred to fresh solutions every few days in order to maintain concentration. Daily germination percentages are presented in Table IV. From these results and from Figure 1, showing the relation between NaCl concentration and final germination percentages, it is clear that the critical NaCl concentration which totally inhibits germination is around 0.3 N. These results do not differentiate between the action of the $Cl^-$ and that of the $Na^+$ ions, neither do they reflect the degree of participation of the osmotic pressure in the inhibitory action of the extract. To clear up these points further experiments were made.

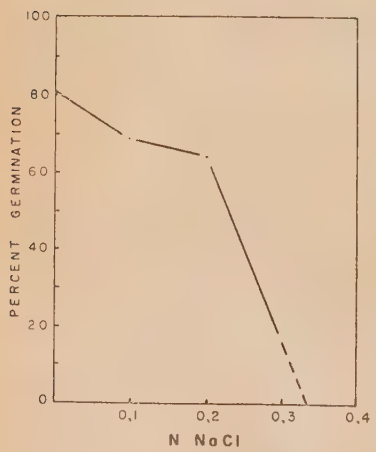

Figure 1

The average weight of a sample of fifty empty (air dried) valves was found to be 216 mg (average of three

lots; S.D. ± 21). Such a sample contains 12.2 per cent (Table III), or 26.35 mg chloride, and when placed in 5 ml water would make up an 0.149 N solution of chloride. Fifty valves in 5 ml water completely inhibit germination of *Zygophyllum* seeds, but it takes a 0.3 N solution of NaCl to achieve the same result, while a 0.15 N solution permits ca. 60 per cent germination (Figure 1). It seems, therefore, that chloride (at least as NaCl) cannot account for the inhibitory action of the extract. It was, therefore, decided to try the combined action of the various ash constituents.

A solution of the same mineral composition and concentration as produced by fifty air dried valves in 5 ml water was made up, according to the assumed composition (Table IV). This solution contained 209.5 mg $CaSO_4$, 93.8 mg $CaCl_2 . 2H_2O$, 70.8 mg

TABLE IV

*Effect of NaCl concentration on rate of germination of seeds of* Zygophyllum dumosum *at* 20°C

| *NaCl solution* | | *Days germination* | | | | | |
|---|---|---|---|---|---|---|---|
| *Conc. (N)* | *Osm. press. (atm)* | 4 | 6 | 8 | 10 | 12 | 14 |
| 0.0 | 0.00 | 68 | 80 | 80 | 80 | 80 | 80 |
| 0.1 | 4.33 | 40 | 68 | 68 | 68 | 68 | 68 |
| 0.2 | 8.39 | 8 | 42 | 60 | 60 | 60 | 60 |
| 0.3 | 12.48 | 0 | 12 | 12 | 16 | 16 | 16 |
| 0.4 | 16.57 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.5 | 20.96 | 0 | 0 | 0 | 0 | 0 | 0 |

KCl and 208.7 mg NaCl per 100 ml water. Duplicate lots of *Zygophyllum* seeds (thirty five seeds each) were germinated in four different dilutions of this solution at 20° C in the dark; two similar lots were germinated in distilled water as controls. Germination percentages on the fourth and tenth days are shown in Table V.

TABLE V

*Effect of a mixture of inorganic salts on germination percentages of seeds of* Zygophyllum dumosum. *Explanation in text.*

| *Concentration of extract* | *Days germination* | | | |
|---|---|---|---|---|
| | 4 | | 10 | |
| | % | *S.D.* | % | *S.D.* |
| 100% | 87.5 | 2.1 | 89.0 | 0.0 |
| 80% | 78.5 | 21.6 | 80.0 | 19.8 |
| 60% | 91.0 | 0.0 | 94.0 | 4.2 |
| 40% | 93.0 | 5.7 | 93.0 | 5.7 |
| 0% | 87.0 | 5.7 | 88.5 | 7.8 |

It is clear from the results that the solution had no effect on germination, and, if its composition is actually similar to the mineral composition of the valves, it may be deduced that the inhibitory action of the substances diffusing from the valves has nothing to do with their mineral content or concentration.

The osmotic pressure of an extract of fifty empty valves in 5 ml water was found to be 8.65 atm. (S.D. – 0.31, average for three determinations, valves extracted at 26° C during twenty four hours). Osmotic pressures of 0.2 and 0.3 N NaCl solutions are 8.39 and 12.48 atm. respectively (Walter 1931), and germination of *Zygophyllum* at

these concentrations is 64 and 16 per cent respectively (Figure 1). It seems unlikely, therefore, that the osmotic pressure of the extract is responsible for its inhibitory action.

### *Drying effects*

The effects of the high relative humidity to which the seeds are subjected within the fruit owing to the hygroscopic qualities of the valves were investigated.

TABLE VI

*Effect of pre-drying on germination percentage (on the 12th day) of seeds of* Zygophyllum dumosum

| | 20°L | 20°D | 26°L | 26°D |
|---|---|---|---|---|
| Seeds pre-dried | 78 | 88 | 64 | 66 |
| Controls | 92 | 94 | 64 | 72 |

The germination of seeds which were subjected to prolonged desiccation over $CaCl_2$ at 30° C was compared to that of non-desiccated seeds freshly extracted from the valves. Germination percentages on the twelfth day under various germination conditions (fifty seeds per lot) are presented in Table VI.

From these results it seems that pre-drying might have a slight retarding effect on germination under various conditions. In addition, seedling growth from pre-dried seeds was markedly retarded as compared with the controls. The hygroscopic qualities of the valves may, therefore, serve to maintain a higher viability and vigour in the seeds under the arid conditions in the desert.

## CONCLUSIONS

The germination regulating mechanisms in *Zygophyllum* seem, on the whole, to be rather simple. The sole regulation against sporadic germination apparently consists in the presence of a water-soluble inhibitor in the fruit coat of the dispersal unit. By requiring a certain amount of rainfall before it is leached away, the inhibitor ensures a minimal addition to soil moisture before germination takes place. As soon as this inhibitor is washed away, germination occurs over a wide range of temperature and conditions of illumination. Germination, therefore, depends almost exclusively on rainfall.

## SUMMARY

Germination of seeds and dispersal units of *Zygophyllum dumosum* (collected in 1952 and 1953) was investigated.

A water-soluble inhibitor in the fruit coat inhibits germination in the dispersal units.

Air dried fruit coats contain approximately 30 per cent ash, 40 per cent of which is chloride.

The chloride contents of the fruit coats, their mineral composition and the osmotic pressure they create in the germination medium were found insufficient to explain their inhibitory action. The organic nature of the inhibitor is inferred.

The seeds germinated well between 16° and 26° C. Within this range, germination was not affected by the age of seeds, temperature or light.

The fruit coat is very hygroscopic. The high relative humidity created within the fruit apparently maintains a slightly higher viability and vigour of the seeds.

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# EXPERIMENTS ON THE GROWING OF KENAF (*HIBISCUS CANNABINUS*) IN ISRAEL

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## INTRODUCTION

The experiments outlined in this paper were designed to study the possibility of growing Kenaf under Israel conditions. From experience gained in other countries, it would appear that the main advantages of this crop as a jute substitute consist in the comparative ease of mechanical harvesting and processing and in greater adaptability to low soil fertility.

## PRELIMINARY EXPERIMENTS (1952)

Out of five sowing dates starting late in February, the June sowing appeared to give best results. It produced the most rapid growth, although the final height was rather less than from earlier sowings. As the June sowing also gave the shortest growing period, it would obviously offer the advantage of reduced water requirement.

El Salvador*, the variety employed in these experiments, came into flower about the middle of October, evidently in response to the shortening daylength. The fact that the plants from the earliest sowing dates flowered as early as the end of June and the beginning of July is probably accounted for by short-day induction during the early stages of growth.

A thick stand (137 plants per square metre) proved clearly superior to thinned plots (30 plants per square metre) as regards the amount of green matter and the total yield of fibres as well as the relative fibre content.

Fibres were obtained for experimental purposes by retting whole stalks for 14 days and subsequent separation of the cortex by hand, or by first passing the stalks through a decorticating machine and then retting for three days.

The maximum absolute quantity of fibres was obtained from the lower part of the stalk (up to 110 cm), while the maximum percentage of fibres was contained in the middle portion (from 110 cm up to 220 cm).

Extrapolation of results obtained from a small plot gave a yield of almost 8 tons per dunam of green matter, with a fibre content of 5.5 per cent. The total yield of fibres amounted on this basis to about 430 kg per dunam. These results compare favourably with those of Crane (1937) and Crane and Acuna (1945). The yield of sound seeds

* El Salvador is a heterogeneous variety mixture, including both *viridis* and *vulgaris* strains considered suitable for fibre production in kenaf growing countries of South America. Seed for our experiments was obtained through the kind offices of Dr. Fastlicht, Honorary Consul of Israel in Mexico.

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harvested from patches left over to the stage of full ripening worked out at 35 kg per dunam, in spite of severe infestation by nematodes and cotton pests. This is somewhat less than the yields of seeds obtained in other countries (Walker and Sierra 1950, Dounin 1929).

Spinning and weaving tests* indicated that the fibres were most suitable for the production of sacking material.

## DATE OF SOWING AND SPACING EXPERIMENTS (1953)

### *Date of Sowing*

The experiment was carried out in six replicates in randomized blocks. Each plot measured 6 square metres and contained 8 rows 15 cm apart, while the spacing within the row was 2—3 cm. Seed of the variety El Salvador was sown at the rate of 5.25 kg per dunam in a sandy loam soil. Fertilizer application consisted of 30 kg monophos (18.5% N, 48% $P_2O_5$) and 15 kg potassium chloride (62% $K_2O$) per dunam. Overhead irrigation amounting to a total of 750 $m^3$ per dunam was applied at ten day intervals.

The rate of germination showed a correlation with soil temperature prevailing during the various sowing periods. The average weekly growth increment amounted to 10—20 cm, except for the plants from the March sowing which were considerably retarded during the first month of growth. Plants sown in July developed normally during the first six weeks, whereupon growth was arrested and, at the time of harvest, the height attained was only about 120 cm compared with an average of 250 cm for the other sowing dates.

The first flower buds appeared on September 27th and flowering commenced on October 7th, irrespective of sowing date, and continued until November 4th. Most of the flowers opened during the second and third week of the blooming period.

TABLE I

*Some data relating to the various sowing dates*

| *Date of sowing* | *Soil temp. at depth of 25 cm (°C)* | *Hrs. required for complete germination* | *Date of harvest* | *Age of plants at harvest (days)* |
|---|---|---|---|---|
| 27.3.53 | 11.9 | 120 | 11.9.53 | 156 |
| 3.5.53 | 24.0 | 82 | 1.9.53 | 125 |
| 10.6.53 | 27.0 | 72 | 9.10.53 | 125 |
| 20.7.53 | 29.9 | 60 | 9.10.53 | 85 |

Results relating to vegetative development and the yield of fibres are given in Table II. Samples of 6 kg from each plot were used for fibre extraction (see 1952 experiments).

Of the four sowing dates investigated, June sowing proved to be most suitable. Later sowing apparently does not allow sufficient time for vegetative growth of the kenaf plant, which in Israel seems to terminate at the end of September or the beginning of October. Rather similar conclusions were reached by Crane *et al.* (1946) in Cuba. El Kilany (1939) is of the opinion that in Egypt kenaf under irrigation can be planted

* The tests were performed at the factory of Mr. Chaim Yerushalmi in Ramat Gan. The existing machinery was used without any difficulty.

from February until mid-June but, in view of the fact that ripening is practically simultaneous for all dates, he recommends late planting: May or June. As far as fibre production is concerned, it seems that mid-June is the best planting time; but to ensure full utilization of machinery and better distribution of labour requirements, it is advisable to plant from May until the end of June.

TABLE II

*Effect of sowing date on the vegetative development and fibre yield (mean values)*

| *Sowing date* | *Length of stalk (cm)* | *Diameter of stalk at base (cm)* | *Weight of shoots per 1 m² (kg)* | *Fibre content (%)* | *Weight of fibres per 1 m² (kg)* |
|---|---|---|---|---|---|
| March 27 | 223 | 0.96 | 7.45 | 4.92 | 364 |
| May 3 | 216 | 0.87 | 6.45 | 4.59 | 297 |
| June 10 | 197 | 0.97 | 7.28 | 5.94 | 432 |
| July 20 | 97 | 0.47 | 1.85 | 3.66 | 67 |
| F | 355** | 73** | 53** | 8.7** | 45** |
| L.s.d. P=0.05 | 9.7 | 0.08 | 1.15 | 0.99 | 75.3 |
| P=0.01 | 13.7 | 0.12 | 1.66 | 1.43 | 108.2 |

The growth renewing capacity was studied in plants cut on August 12 down to a height of 15 cm from the ground. New shoots sprouted on the stumps from the uppermost axillary buds. The shoots developed well, reaching a height of 100—200 cm, and came into flower on October 7, i.e. together with uncut plants.

### *Spacing*

Spacing experiments were carried out under conditions similar to those of the date of sowing experiments. Four spacings were compared: 15, 30, 45 and 60 cm between the rows, while the distances within the row were maintained at 2—3 cm in each case. The weight of seed used per dunam worked out at 5.25 kg for plots spaced 15 cm, and proportionately less for the wider spacings. Sowing was made on June 12, 1953 and harvest took place on October 12, giving a growth period of 126 days. The experiment was carried out in randomized blocks with 5 replications, each plot covering an area of 10.8 m².

TABLE III

*Effect of spacing on the vegetative development and fibre yield (mean values)*

| *Distance between rows (cm)* | *Number of plants per 1 m²* | *Length of stalk (cm)* | *Diameter of stalk at base (cm)* | *Weight of shoots per 1 m² (kg)* | *Fibre content (%)* | *Weight of fibres per per 1 m² (g)* |
|---|---|---|---|---|---|---|
| 15 | 277 | 202 | 0.76 | 5.50 | 5.18 | 284 |
| 30 | 115 | 234 | 0.98 | 6.10 | 5.77 | 352 |
| 45 | 70 | 223 | 1.04 | 5.06 | 6.10 | 317 |
| 60 | 62 | 241 | 1.15 | 5.28 | 5.52 | 289 |
| F | 35** | 5.91* | 84** | 0.65 | 3.62* | 1.03 |
| L.s.d. P=0.05 | 58 | 21 | 0.06 | | 0.75 | |
| P=0.01 | 83 | 30 | 0.07 | | | |

* Significant (P = 0.05)

** Highly significant (P = 0.01)

There were no significant differences due to spacing in the yield of shoots and their fibre content. Under the closest spacing, the stems were too thin; with rows 60 cm apart they were excessively thick. The optimal thickness of about 1 cm was recorded for the intermediate spacings. It seems that, with irrigation, the most suitable spacing under Israel conditions is between 30 and 45 cm.

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## A micro moist chamber for fruit inoculation *

In pathogenicity tests of fungi it is common to maintain high humidity by keeping the inoculated plant or fruit under a glass bell-jar. Such a moist chamber, however, has its disadvantages:

1) The whole fruit is under the jar and its metabolites may influence the results of the inoculation.

2) Contaminants or development of latent infection — likely to occur under such conditions because of high humidity — may mar the results of the experiment.

3) Condensation of water on the jar may interfere with the observation of the inoculated fruit.

4) The method requires space and is cumbersome in the case of large-scale experiments.

The above difficulties may be successfully overcome in inoculation experiments by covering only the place of inoculation with a small bell, which serves as a micro moist chamber. This may be easily and cheaply prepared from a broken test tube**) (15-17 mm outside diameter) by cutting off its bottom at the height of 12-14 mm. For cutting the tube a carborundum disc was used and thus a polished cut was obtained which does not injure the fruit.

* Agricultural Research Station, Rehovot 1954, Series No. 80.

** Thick-glass tubes are inferior, since the transparency of the bell may be impaired.

Figure 1

After the local inoculation had been carried out, a sterilized bell was put in place, covering the inoculation point, and attached to the fruit with melted paraffin (Figure 1).

The addition of water, practised in the moist chamber method, is here unnecessary; the small amount of water brought with the suspension is sufficient to maintain high humidity under the bell.

This method has several advantages:

1) Conditions generally required in inoculation experiments (e.g. high relative humidity, protection of inoculum, prevention of contamination, etc.) are obtained.

2) Almost the whole fruit remains under normal conditions, thus securing a clear picture of the host — parasite relationship.

3) The progress of the infection at its various stages is easily observed.

4) Such a fruit, with the inoculation point covered with a small bell, is easy in handling and may also be stored either under commercial or under controlled conditions.

5) The method is convenient for large-scale experiments, enables sterilization of the bells, and is cheap.

6) More than one bell may easily be used on one fruit.

The above method was used in our inoculation experiments with citrus fruits during several seasons and was found to be very satisfactory.

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## New observations on gall-producing aphids on Pistacia atlantica in Israel

Early collectors of galls from the Eastern Mediterranean reported *Pemphigus cornicularius* Pass., *Pemphigus utricularius* Pass., *Pemphigus riccobonii* Stef. and *Pemphigus semilunaris* Pass. from *Pistacia atlantica*[1]. Wertheim[2] recorded four species from the same tree. Recent laboratory rearing of the virginogeniae on grasses and *Leguminosae* as well as a re-examination of the fundatrigeniae revealed that actually five diferent species of aphids cause gall formation on *P. atlantica:*

*Trifidaphis phaseoli* Pass. 1860
*Forda mordvilkoi* Börner 1950
*F. riccobonii* Stef. 1899
*Slavum* sp.
*Geoica utricularia* Pass. 1856


Galls on *Pistacia atlantica:* 1. *Slavum* sp., 2. *Forda riccobinii*, 3. *F. mordvilkoi*, 4. *Trifidaphis phaseoli*·

*Pemphigus cornicularius* Pass., which is a synonym of *Baizongia pistaciae* L., was never found on this species of *Pistacia.*

*Trifidaphis phaseoli* Pass.

Synonymy: *Forda derbesi* (Bodenheimer 1937, Wertheim 1954 nec Licht., 1880).

The gall produced was first described by Mordvilko[5] from *P. mutica* (Nikitski Garden near Yalta, S. Crimea). The yellow-green, or crimson, spindle shaped galls produced mainly at the base of the leaflet have been known in this country for years. They were erroneously identified as *F. derbesi* Licht. (*F. derbesi* Licht. is a nomen novum for *Pemphigus pallidus* Derbes and is identical with *Paracletus cimiciformis* Heyden). The virginogeniae reared from larvae born from winged migrants are now identified as *T. phaseoli;* the fundatrigeniae are also identical with those described by Mordvilko. This author has not, however, described the temporary galls formed by the fundatrix which can be found in early spring before the definitive galls develop.

*T. phaseoli* has been found in Israel on various

*Leguminosae* and to a lesser degree on *Gramineae*. The present identification of the galls on *P. atlantica* shows that this insect has a two year cycle involving a migration from the *Pistacia* to secondary hosts. Since, however, *P. atlantica* is quite scarce in this country and appears mainly in the hills and in the South, it has to be presumed that in the Coastal Plain the insect is anholocyclic.

*Forda mordvilkoi* Börner

Synonymy: *Forda follicularia* Mordvilko 1935.

The galls formed by this species were found on *P. mutica* and *P. terebinthus* in Southern Crimea. The gall-inhabiting forms and the laboratory reared virginogeniae were described by Mordvilko[5] as *F. follicularia* Pass. Börner[6] recognized it to represent a new species and named it *mordvilkoi* (Mordvilko's *F. follicularoides* is really *F. follicularia* sensu Passerini, Roberti and others).

The pocket-galls, formed by the upward rolling of the leaflet's edge, are at first flat, greatly resembling young galls of *F. follicularia*. Owing to uneven growth, the mature gall is built of swollen, semispherical cells with flat, narrow bands at their junction. Each gall is built of from two to six such cells, their cavity remaining united.

These galls are very numerous and usually appear on the same tree with those of *T. phaseoli*. Galls of these two species can often be found on the same leaflet.

*Slavum* sp.

Synonymy: *Pemphigus* sp. Bodenheimer 1927, *Aploneura* sp. Wertheim 1954.

The gall produced was first described in 1844 by Guibourt, who compared it to a cauliflower (fide Rübsaamen 1902)[8]. The first figure of this gall was published by Rübsaamen[8] from a sample collected in Persia. This author believed it to represent a deformation of the whole inflorescense and described it as coral-like.

The galls begin to develop in June on resting buds. Their rather complicated structure is produced by branching of an original small, cylindrical outgrowth. The biology of their inhabitants differs from that of other gall producing aphids on *Pistacia*[2]. The alatae leaving the galls in autumn are sexuparae and do not migrate to a secondary host. As could be observed last season, they depose the sexuales directly on the bark of the same tree on which the gall developed. The aphids of this species thus remain on the same tree all year round.

A full description of this species as well as that of *F. riccobonii* which is known only from the form of its gall will be published later.

The author wishes to express her thanks to Dr. Hille Ris Lambers for the identification of *Slavum* sp. and to Dr. E. Swirski for his invaluable help and kind advice.

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## Some experiments on pressure effects in photographic emulsions

Recent experiments by Hedges and Mitchell[1] have made necessary a revision of our former concepts on pressure effects in photographic emulsions. Since the important role of dislocations in the photographic process became known, it seemed probable that these play a role in the pressure effects as well.

Previously a desensitization by static pressure was known and this was thought[2,3] to be due to the lowering of ionic conductivity in silver bromide crystals by pressure. Experiments have now been carried out which show clearly that static pressure does not necessarily desensitize, but that it changes the distribution of density between the internal and external latent images.

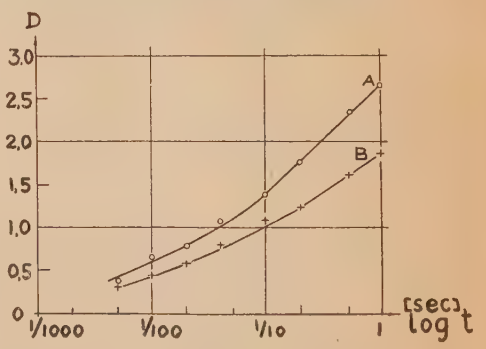


Figure 1

Characteristic curves for *Ilford ordinary* film. A — normal conditions; B — exposed under 500 kg/cm² pressure,

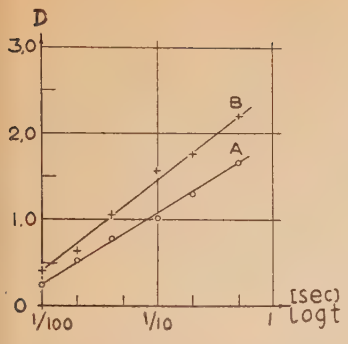


Figure 2

Characteristic curves for internal image of *Ilford ordinary* film. A — normal conditions; B — exposed under 500 kg/cm2 pressure.

Figure 1 shows the familiar desensitization by mechanical pressure. Curve A was obtained by measuring the densities of an *Ilford ordinary* film after illumination with constant intensity for varying times. Curve B was obtained under exactly the same conditions. but the film was subjected during illumination to pressure of about 500 kg/cm2. Both films were developed simultaneously in methol-hydroquinone developer. Figure 2 shows the result of the same experiment, but the films were bathed for four minutes in a 0.2% solution of potassium cyanide before development, i.e. the internal instead of the external latent image was developed. In this case sensitization by pressure instead of desensitization occurred. These results are in agreement with those obtained by Faelens and de Smet[4,5].

We propose tentatively the following interpretation which seems to be the most straightforward: Normally the silver nuclei forming the latent image cluster both on internal grain boundaries and dislocation lines, and on sites provided by sensitization on external crystal surfaces. Under pressure dislocations move and multiply and form new centres of nucleation for silver atoms inside the crystal. This means that more silver will be formed internally and therefore less becomes available to form the external latent image. The ratio of external to internal image therefore is changed in favour of the latter. This can also be seen from Table I, showing that the sum of internal and external densities depends on the exposure only, while their ratio is changed by pressure.

The authors wish to thank Dr. A. Halperin for his kind help in the course of this work.

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TABLE I

*Internal and external densities for various exposures by constant intensity light with and without pressure. Sums of internal and external densities are unaffected by pressure, ratios are affected.*

| $t$ sec | $D_{ext}$ | $D_{int}$ | $D^P_{ext}$ | $D^P_{int}$ | $D_{ext}+D_{int}$ | $D^P_{ext}+D^P_{int}$ | $\frac{D_{ext}}{D_{int}}$ | $\frac{D^P_{ext}}{D^P_{int}}$ |
|---|---|---|---|---|---|---|---|---|
| 1/2 | 2.35 | 1.62 | 1.63 | 2.20 | 3.97 | 3.83 | 1.4 | 0.7 |
| 1/5 | 1.77 | 1.38 | 1.24 | 1.88 | 3.15 | 3.12 | 1.3 | 0.7 |
| 1/10 | 1.40 | 1.09 | 1.04 | 1.56 | 2.49 | 2.60 | 1.3 | 0.7 |
| 1/25 | 1.08 | 0.71 | 0.80 | 1.01 | 1.79 | 1.81 | 1.5 | 0.8 |
| 1/50 | 0.81 | 0.44 | 0.60 | 0.62 | 1.25 | 1.22 | 1.4 | 1.0 |
| 1/100 | 0.57 | 0.24 | 0.40 | 0.34 | 0.81 | 0.74 | 2.3 | 1.2 |

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Received December 24, 1954.

## Grégarine parasites de Coléoptères Ténébrionides d'Israel

Grâce à du matériel récolté sur place lors d'un séjour en Israel en août 1953 ou envoyé depuis par des entomologistes israéliens (Dr. Bytinski-Salz, Dr. J. Wahrman), j'ai pu mettre en évidence des Grégarines dans l'intestin moyen de divers Coléoptères Ténébrionides de ce pays.

Il s'agit d'Eugrégarines appartenant aux familles des *Gregarinidae* et *Stylocephalidae:*

*Gregarinidae*

1. *Gregarina wahrmani* Théodoridès

J'ai décrit cette espèce parasite de *Scaurus puncticollis* Sol. var. *rugicollis* Rche dans un travail sous presse[1].

*Stylocephalidae*

2. *Stylocephalus oblongatus* (Hamm.)

Cette espèce déjà signalée chez divers Ténébrionides d'Europe[2] a été trouvée en Israel chez *Dendarus piceus* Ol.

3. *Stylocephalus phalloides* Théodoridès

J'avais décrit cette espèce chez des *Blaps* d'Iran et du Maroc[2] et l'ai retrouvée chez *Mesomorphus longulus* Reiche et *Erodius puncticollis ecostatus* Crotch d'Israel.

Ce matériel m'a permis d'obtenir le kyste et les spores qui étaient encore inconnus chez cette espèce.

4. *Stylocephalus longicollis* (Stein)

Ce parasite déjà signalé chez plusieurs espèces de *Blaps* a été retrouvé en Israel chez *Blaps sulcata* Cast.

5. *Sphaerorhynchus ophioides* A. Schneider

Des exemplaires de cette espèce trouvés chez des *Akis elevata* Sol. d'Israel ont permis de mettre en synonymie avec celle-ci la Grégarine décrite sous le nom de *Sphaerorhynchus chabaudi* Tuzet et Théodoridès[3].

6. *Cystocephalus algerianus* Schneider var. *mauritanica* Tuzet et Théodoridès. Cette Grégarine se rencontre chez de nombreux Ténébrionides d'Israel (10 espèces et 8 genres: *Dailognatha, Tentyria, Mesomorphus, Zophosis, Adesmia, Tenthyrina, Pimelia, Thriptera*).

Le nombre élevé de ses hôtes ainsi que sa vaste répartition géographique ont été rappelés dans un travail particulier[4].

Toutes ces Grégarines sont nouvelles non seulement pour Israel, mais également pour la faune asiatique; tous leurs hôtes sont inédits.

L'étude détaillé et illustrée de ces espèces paraîtra dans les "Annales de Parasitologie Humaine et Comparée" (Vol. 30, 1955).

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## Brass as a rubber filler

An attempt to create rubber-sulphur-filler bridges as visualized by Studebaker[1] has resulted in a preliminary study of the use of 73/27 brass dust as filler for rubber. As compared to rubber compounds containing equal volume loadings of medium and hard blacks, the brass dust shows a five-fold increase of modulus, but tensile strength and abrasion resistance fell by a factor of about two. Surprisingly, no marked loss of properties was observed on ageing.

Full details will be published elsewhere.

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Received February 2, 1955.

## The agglutinogenic properties of various stages of the Leishmanias

During work on the serology of *Leishmania* sp. immune sera were prepared in rabbits against strains of *L. tropica*, *L. infantum* (a strain of local origin), *L. infantum* (a Kenya strain obtained from Dr. R.B. Heisch of Nairobi), and against a *Leishmania* sp. discovered by Dr. R.B. Heisch (1954) from a lizard *Latastia caudata* in Kenya. In the case of the human Leishmanias two sets of specific sera were prepared, one by intravenous injection of cultures on Locke-serum-agar and Locke-blood-agar, and the other by intravenous injections of suspensions of L.D. bodies from the spleens of heavily infected animals. The suspensions of L.D. bodies were prepared by grinding small fragments of heavily infected spleens in a mortar, adding saline and separating L.D. bodies from the bulk of the tissue by a method described by Adler and Ashbel (1940). Four to six injections of flagellates at intervals of 4—6 days with a total of 300 to 500 x $10^6$ flagellates sufficed to produce a titre of 1 in 500 circ. in the case of the human Leishmanias and 1 in 20,000 and higher in the case of the lizard *Leishmania*. It is interesting to note that the serum prepared against the lizard *Leishmania* was found to contain agglutinins against *L. infantum*, *L. donovani* (Indian strain), *L. brasiliensis* and *L. tropica*. The smallest titres were against *L. tropica* and the highest against *L. infantum* (Kenya strain). A full account of these findings will be given elsewhere.

The sera prepared by injections of suspensions of L.D. bodies showed relatively small titres (from 1 in 10 to 1 in 50) against the flagellate stage of the homologous *Leishmania* sp., although in preparing these sera relatively large numbers of protozoa were used (from 7000 to 10,000 x $10^6$ L.D. bodies). The differences in titre between the two types of sera are not entirely due to the absence of the flagellar component in the L.D. bodies because, as will be shown elsewhere, the flagellar antigens account for only a small part of the titres produced by the injection of flagellates from cultures.

The above findings indicate either that L.D. bodies are relatively poor in agglutinogenic antigens which attain their final characteristics, qualitatively and quantitatively, only during or at the end of development of the L.D. bodies into flagellates, *or* that they absorb and bind antibodies from the vacuoles in which they lie in cells of the reticulo-endothelial system and are therefore only slightly antigenic when injected into rabbits.

The latter possibility suggested itself as a result of observations on the above mentioned lizard *Leishmania*. On medium (Locke-serum-agar) containing 10% specific immune serum inoculated with flagellates this species produces discrete colonies of aflagellar organisms (hypertrophied

L.D. bodies). If the aflagellar organisms from cultures on 1 in 10 immune serum from which they have presumably absorbed antibodies are centrifuged and washed repeatedly in saline and then used for producing immune sera in rabbits, titres no higher than 1 in 20 to 1 in 50 are produced.

Further experiments are required to explore the above two possibilities as explanations for the low titres produced in rabbits by the intravenous injection of L.D. bodies from the spleens of infected hamsters.

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## Sedimetric method for potassium and ammonium determination

A sedimetric method for potassium determination based on the low solubility of alum in concentrated solutions of aluminium sulphate[1] dealt with analysis of salts containing only chlorides. In further experiments, it was found that this method could be adapted to potassium determination in sulphates and nitrates.

For Figure 1, 10 ml potassium sulphate solution (analytical reagent) containing 1 g salt were mixed with 15 ml aluminium sulphate solution ($d = 1.33/25°C$) at 20°C and 25°C, and the volume of precipitated alum was read after centrifugation. For the analysis of potassium sulphate, 25 g of the salt were dissolved and mixed with water in a 250 ml volumetric flask, and 10 ml (corresponding to 1 g salt) was analyzed. In case the potassium sulphate contains amounts of potassium chloride greater than 10%, special graphs have to be prepared.

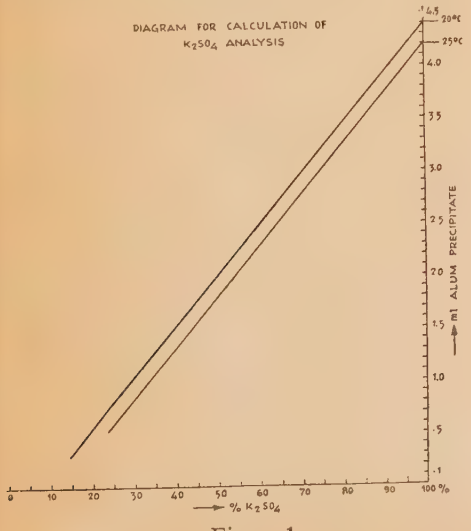


Figure 1

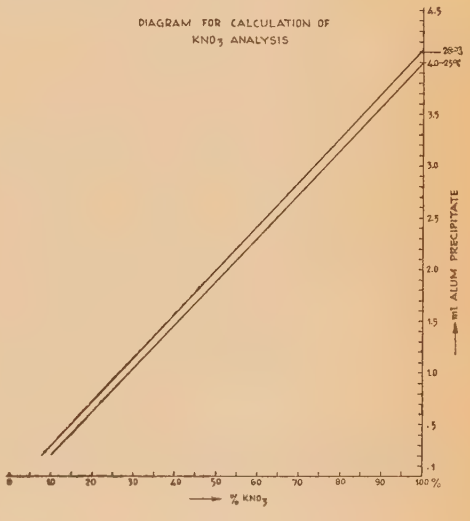


Figure 2

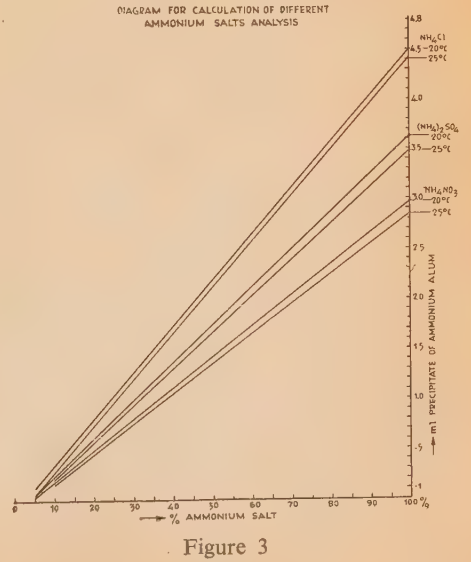


Figure 3

For Figure 2, 5 ml potassium nitrate solution (analytical reagent) containing 1 g salt were precipitated at 20°C and 25°C with 15 ml aluminium sulphate solution ($d = 1.33/25°C$) and after centrifugation the volume of the precipitated alum was read. When analyzing potassium nitrate, 20 g of the salt were dissolved and mixed with water in a 100 ml volumetric flask. After filling up with water to the mark and mixing, we analyzed 5 ml (corresponding to 1 g salt). Here, also, special graphs must be prepared if the potassium nitrate contains more than 10% of other salts, such as potassium chloride, potassium nitrate etc.

Experiments on similar application of the sedimetric method to the analysis of ammonium salts gave satisfactory results. Solutions of ammonium nitrate (analytical reagent) were precipitated with aluminium sulphate solution at 20°C and 25°C in the same way described above for potassium salts, using amounts of solution corresponding to 0.5 g ammonium salt. Figure 3 illustrates the relationship of volume of precipitated ammonium alum to the amount of ammonium salt present in the solution. For analysis, 25 g of the salt should be dissolved and mixed with water in a 100 ml volumetric flask. 2 ml corresponding to 0.5 g salt are mixed with 15 ml aluminium sulphate solution ($d=1.33/25°C$) in a centrifugal tube as described[1].

Centrifugation was carried out at 1500 r.p.m. for one minute (not, as erroneously stated[1], at 3000 r.p.m. for 10 minutes).

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Received October 28, 1954.

## Direct unambiguous display: A new method with the Fabry-Perot interferometer for emission and absorption

The most satisfactory device for very high resolution spectroscopy is the Fabry-Perot interferometer. Its main practical disadvantage has been that, for a given instrument, the available spectral range was inversely proportional to the resolving power. This situation has long been accepted as inevitable by spectroscopists and is looked upon as the main inherent disadvantage of interference spectrometers in general.

Thus hyperfine structures much wider than the spectral range of the interferometer could not be observed directly, but only inferred by comparison of two or more interferograms taken with different plate spacers. Much work, calculation and speculation has been necessary to unravel the details of all but the simplest structures.

A method has now been developed by means of which the Fabry-Perot interferometer can be made to display directly an extensive spectrum with high resolution. There is no overlapping of orders and in fact no part of the spectrum is repeated at all. The entire structure is displayed in asingle order while neighbouring orders are completely removed. We have called it the method of "Direct Unambiguous Display" (DUDE).

All interference spectrometers work on the following principle. When the optical path difference is equal to a whole number $m$ of a certain wavelength $\mu$, then that wavelength is transmitted. Thus by varying the path difference it is possible to display a spectrum. In the Fabry-Perot interferometer the path difference is given by $2nt\cos\theta$. The plates are separated an amount $t$, the intervening medium having a refractive index $n$. The angle $\theta$ is the angle of refraction within the medium. This path difference can be varied by manipulation of $n$, $t$, or $\theta$ and in photographic work it is usual to use the latter. This leads to the familiar circular "fringes of equal inclination". A system which can be used with photoelectric recording is to view only a small central portion of the pattern ($\theta=0$) and vary the path difference by varying $t$ or $n$. The index $n$ can be varied conveniently by pumping the air between the interferometer plates. The information given by the recorded trace is the same as that given by the extended ring pattern.

Now suppose that for a given $t$ and $n$ ($\theta=0$) a wavelength $\lambda$ is passed at order $m$. Then at the same time wavelengths $...\lambda_{-2}, \lambda_{-1}, \lambda_{+1}, \lambda_{+2}...$ will appear superimposed upon it corresponding to orders $...m-2, m-1, m+1, m+2...$ These overlapping orders confuse the spectrum and need to be removed. The nearest ones, $\lambda_{-1}$ and $\lambda_{+1}$, are $\lambda^2/2nt$ away from $\lambda$, so that if a monochromator be placed behind the interferometer and pass a waveband of width $\lambda^2/2nt$ with $\lambda$ in the middle, there will be no overlapping. Now suppose further that as $n$ is varied by pumping air, and as the transmitted wavelength $\lambda$ is thus varied, the monochromator is moved up accordingly so that at all times only the wavelength corresponding to the self-same order $m$ is observed. The result will be a direct unambiguous display of the spectrum. The range attainable by pumping air is $\lambda(n_0-1)$, where $\lambda$ is the wavelength

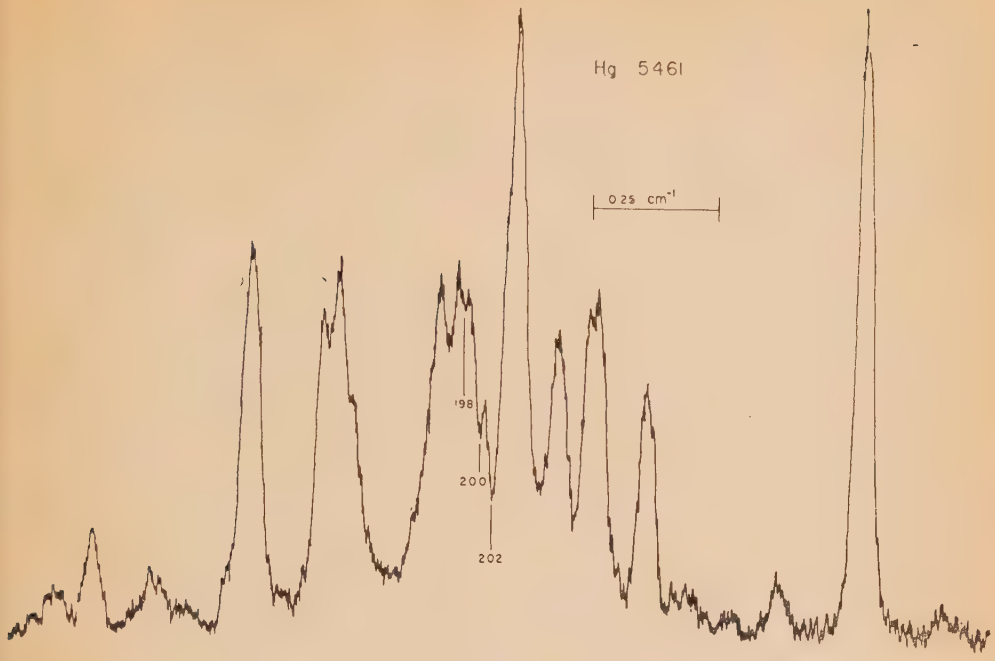


Figure 1

Direct unambiguous display of the hyperfine structure of the mercury green line. The resolving power is 1,800,000. The total width of the line is about ten times the spectral range of the interferometer that was used to examine it.

of the region and $n_0$ the refractive index of air. It can be changed by using other gases.

The optical path difference within the interferometer must be varied smoothly, but the motion of the monochromator may be quite crude, provided that it masks off the neighbouring orders with a margin of say $\lambda^2/8nt$, one quarter of the range between the orders. Of course for very high resolution the monochromator must still be a good one. If a resolving limit of $\Delta\nu$ cm$^{-1}$ is required of the interferometer, then the resolving limit of the monochromator must be about $\Delta\nu \cdot 3R^{1/2}/(1-R)$, where $R$ is the reflectivity of the plates. In other words, the monochromator must resolve an interval equal to the spectral range between orders of the interferometer.

The accompanying figure shows a trace of the green mercury line produced by a low pressure arc. The width of the pattern is about 1.5 cm$^{-1}$, or ten times greater than the spectral range of the interferometer that was used to examine it.

DUDE is equally applicable to absorption spectra. We have already applied it with success to absorption studies under very high resolution at 1.5$\mu$.

Full details will be published elsewhere.

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### On the occurrence of hail in Israel

The occurrence of hail in Israel is casual and infrequent. Therefore considerable interannual variations may be expected in the number of cases and number of days with hail. The difficulty in evaluating any statistics of hail at various stations lies in the uncertainty whether or not the observer did really record all cases, also those which occurred out of the usual times of observations, e.g. at night and in early morning hours. For this reason we cannot yet outline the regional distribution of hail frequency. However, it is possible to describe in detail the seasonal distribution at one station, Lod Airport (in the centre of the coastal plain of Israel), at which hourly observations have been carried out during 8

| *Month* | *No. of days* | *No. of cases* |
|---|---|---|
| January | 7 | 10 |
| February | 14 | 21 |
| March | 4 | 8 |
| April | 4 | 5 |
| May—October | 0 | 0 |
| November | 2 | 6 |
| December | 6 | 10 |
| Annual Total (8 years) | 37 | 60 |

whole years. The following table includes the totals of all cases of hail recorded at Lod Airport and the corresponding numbers of days with hail*, for each month of the years 1945-47 and 1950-54.

The table shows that hail occurs in a season from November to April, and is more frequent in the middle of the season than at its extremities, February having the greatest frequency of incidence. More detailed data show that there may be a season with hail only in its central months, January and February (i.e. season 1950/51), and, on the other hand, there may be one in which hail occurred only at its extremities, November-December and April (1953/54).

The rareness of hail in October and May (the two extremities of the rainfall season in the Mediterranean climate of Israel) means nothing about the size of hail or the duration of fall when it does occur in these months. Two cases are specially notable: On October 15, 1937, hailstones several centimetres in diameter fell at Petah Tiqva (near Tel Aviv); normally the diameter of grains does not exceed ½ cm but in several cases a size of pigeon eggs was noted. On May 11, 1944, during a severe thunderstorm in the Beisan Valley, hail fell at Sde Eliahu for half an hour continuously, while generally the fall of hail is of rather short duration. In both cases heavy damage was caused.

As for the diurnal variation of hail, it appears (data of Lod Airport) that hail, like rain, may be expected at any time of the day or night; but, unlike rain, no clear tendency may be discerned in the 24-hourly frequency distribution of hail occurrences towards any hour of maximum or minimum. It may also be stated that occasionally 2—3 cases of hail were registered on the same day, sometimes even 4—5.

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* Assuming the definition of a hail day to be identical with that of a rain day, i.e. a period of 24 hours commencing at 08 L.ST.T. on the indicated date.

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## Effect of antihistaminic drugs on nidation and pregnancy

It is an established fact that in order to induce pseudopregnancy and formation of deciduoma in the non-pregnant uterus two conditions are essential:

a) the proper combination of oestrogenic and progestogenic hormones acting on the uterus,

b) a non-specific irritant for the endometrium.

Recently, Shelesnyak[1,2] suggested that histamine may be the non-specific irritant released by the endometrium since intra-uterine histamine injections produced gigantic decidual cell reactions. By injecting an antihistaminic drug such as diphenhydramine (benadryl) into the uterine lumen, he was able to suppress the formation of deciduoma.

We have tried to prevent the nidation of the egg by treatment with antihistaminics in female mice, following the work of Shelesnyak.

### MATERIALS AND METHODS

Forty female and 15 male mice (Hebrew University strain) were kept in cages in groups of 5 females and 2 males. Injection of antihistamine was given twice daily in a dose of 100 gamma in 0.1 cc water subcutaneously to each mouse. This was the highest dose of antihistamine tolerated by mice without severe reaction during a period of treatment lasting 6 weeks. Ten females placed together with 4 males served as controls. The following antihistaminic drugs were injected:

Benadryl: Diphenhydramine hydrochloride (Parke Davis)

Pyribenzamine: Tripelennamine hydrochloride (Ciba)

Histadyl: Thenylpyramine hydrochloride (Lilly)

Trimeton: Prophenpyridamine maleate (Schering)

Tagathen: Chlorothen citrate (Lederle)

Decapryn: Doxylamine succinate (Merrell)

### RESULTS

The results compiled in Table I clearly show that there was no anti-conceptional effect demonstrable in the 6 antihistaminic preparations tested. The mice became pregnant within 6 weeks both in the control cages and in the experimental cages. Both groups developed a normal pregnancy and had a normal number of litters ranging from 5 to 10.

TABLE I

*Development of pregnancy during a 6-week treatment with antihistaminic drugs*

| *Treatment* | *Daily dose* (γ) | *No. of animals* | *No. of pregnant animals* |
|---|---|---|---|
| Benadryl | 2 x 100 | 5 | 3 |
| Pyribenzamine | 2 x 100 | 5 | 2 |
| Histadyl | 2 x 100 | 5 | 3 |
| Trimeton | 2 x 100 | 5 | 5 |
| Tagathen | 2 x 100 | 5 | 4 |
| Decapryn | 2 x 100 | 5 | 3 |
| Control | — | 10 | 8 |

DISCUSSION

The experiments reported show that antihistaminic drugs administered subcutaneously cannot suppress implantation and normal development of fertilized ova in the uterus. These experiments do not, however, contradict the results obtained by Shelesnyak, since in his experiments only the development of pseudopregnancy and decidual growth was tested, no blastocysts being involved. Shelesnyak's experiments prove that an antihistamine drug can only counteract the non-specific irritant effect of histamine produced by the agents which induce the decidual reaction. It cannot, however, counteract the specific effect of nidation of a fertilized ovum and the normal development of the trophoblast and of pregnancy.

I am indebted to Mr. Zawojski for his devoted help.

NOTE ADDED IN PROOF:

After this paper was submitted for publication, there appeared a paper by Goldstein A. and M. M. Hazel, (Harvard Medical School, Boston): Failure of an antihistaminic drug to prevent pregnancy in the mouse, 1955, *Endocrinology*, **56**, 215.

These authors have fully corroborated the results reported in this paper.

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**The nutritional value of oven-dried Chlorella** Although much work is at present being carried out in the mass culture of *Chlorella*, little information is available regarding its nutritional value. *Chlorella* was grown in large tanks and under the culture conditions previously described[1], the only change in the medium being the addition of EDTA at the rate of ½ g/litre. During a period of eight months, no sign of infection of these septic open tanks was noted. Neither foreign algae nor protozoa, rotifers, etc., appeared.

The algae were separated by allowing them to settle for 24 hrs, removing the supernatant, and centrifuging the concentrated algal solution in an MSE medium centrifuge using a basket head padded with filter paper. The algae were oven-dried at 80° to 90° C.

Three different methods were used for assaying the nutritional value of *Chlorella:* a) the effect on chicks, b) nitrogen balance in rats and c) a microbiological test in *Staphylococcus faecalis*.

a) One group of chicks were fed for 39 days on 20% wheat bran, 10% fish meal, 10% milk powder, 10% groundnut cake, 10.4% barley, 37% white maize, 2% sea shells and small amount of salt, aurofac, sulfaquinoxaline and ribopan. In a second group of chicks 10% *Chlorella** powder was substituted for the 10% groundnut cake. The chicks accepted the second diet as well as the first, and there was no adverse effect on their health or development. The gain in weight of the latter chicks was slightly less than that of the first group (Cf. Combs[2]).

b) From feeding experiments on rats — using Mitchell's nitrogen balance method — the biological value and digestibility of the protein were found to be 6 and 32% respectively. The *Chlorella* was excreted with the cell wall intact. Autoclaving the *Chlorella* for 1 hour at 1 atm. did not appreciably alter the results. Freeze drying[3] causes rupture of the cell wall and greatly improved digestibility. But freeze drying is not practical for the treatment of bulk quantities of *Chlorella*.

c) A microbiological evaluation of the protein was carried out[4]. *C. vulgaris* powder was digested with pancreatin and brought to the same amino N concentration as similarly treated casein. Its biological value was then found to be 26% of casein. If the algae were first autoclaved and then treated as before, the value rose to 37%. This treatment did not improve the low digestibility towards pancreatin which remained 1/3 that of casein. The biological value based on an equal amino N concentration therefore compares favourably with that of other vegetable proteins (Gluten 15%).

We wish to acknowledge the cooperation of A. Bondi and A. Ascarelli of the Agricultural Experiment Station, Rehovot, for carrying out experiments described under a), of K. Guggenheim of the Laboratory of Nutrition, The Hebrew University — Hadassah Medical School, Jerusalem, for experiments b) and of N. Grossowicz

* The oven-dried *C. vulgaris* prepared here and a freeze dried American *C. pyrenoidosa*, kindly presented by Prof. S. Lepkovsky, were used.

and S. Halevy of the Department of Bacteriology, The Hebrew University—Hadassah Medical School, Jerusalem, for experiments c).

We wish to thank the Ministry of Agriculture for the grant which supported this work.

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## Cooley's Trait in Oriental Jews*

Schieber[1] reported the occurrence of Cooley's trait in members of a Bukharian Jewish family. Yunis[2] recently observed Cooley's anemia in Oriental Jewish children, and Matoth[3] and his coworkers in Kurdish children.

A high incidence of Cooley's trait was noted by the author in members of three families of Oriental Jews, one from Kurdistan, one from Urfa, and one from Nesibin (Kashmili Jews). The latter two towns are in the southeastern corner of Turkey.

Diagnostic criteria for Cooley's trait were high red cell counts in the presence of a relatively low haemoglobin (as i.e. in one case 6,650,000 red cells/cmm$^3$ and 12g haemoglobin), increased resistance of the red cells to hypertonic salt solutions and the morphological changes typical for Cooley's trait. At least 17, and possibly 20 out of the 32 members of the families examined were found to carry the trait.

Since the 3 index cases of these 3 families were admitted to the hospital because of rheumatic heart disease — a diagnosis proven at post mortem examination in 2 of them — a search was carried out also for the incidence of this disease in these families.

Rheumatic heart disease was diagnosed where clinically and roentgenologically demonstrable lesions were present. Eleven, and possibly 13 out of the 32 had rheumatic heart disease.

Eight, and possibly 10 had both Cooley's trait and rheumatic heart disease. Further data and results of the examination of the blood groups of the individuals will appear elsewhere[4].

The appearance of Cooley's trait is genetically determined; the susceptibility to rheumatic disease is also considered to be so conditioned. However, whether anything more than a chance relation exists between these two conditions in the patients so affected in this series can at present not be decided, but is the subject of further investigation.

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* This work was supported by Hadassah Medical Organiatizon Research Funds.

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# Proceedings

## of The Second Meeting of The Israel Physical Society

Held at The Hebrew University of Jerusalem December 19—20, 1954.

CONTENTS

# SYMPOSIUM ON COSMIC RAYS

**Theories of origin of cosmic rays,** P. M. S. BLACKETT, *Imperial College of Science and Technology, London*[1].

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**Extensive air showers,** KURT SITTE, *Department of Physics, Technion — Israel Institute of Technology, Haifa.* It may be said that present-day interest in air shower research centres upon two features: from the astrophysical point of view, further study on the spectrum of shower primaries and on their spatial distribution is desired, and from the angle of nuclear physics, the possible occurrence, at high energies, of new types of interactions and particles must be explored. In the following, a number of experiments will be briefly discussed — most of them carried out by the Syracuse group* between 1951 and 1954 — designed to contribute to a future solution of the complex problems involved.

Let us consider the energy spectrum first. Here it should be noted that the usual conclusion: to identify the experimentally determined energy distribution of air showers with the primary spectrum, is correct only if the fraction of the primary energy which is transferred to the electronic component remains the same for primaries of all energies. This customary assumption can be checked by using the penetrating shower component as a monitor. A constant abundance ratio of the shower particles over a wide range of primary energies would indicate a constant fractional energy transfer to the various components, and hence justify the "classical" procedure.

By using a coincidence-anticoincidence arrangement as shower selector, events in a comparatively narrow energy band can be picked out. In order to record showers containing penetrating particles likewise from the same energy band, counters of different sensitive area have to be employed for the triggering. Furthermore, events of different energies have to be observed at different altitudes, so that they are in the same stage of cascade development. If all these precautions are taken, one finds that for showers in the region above $10^{13}$ ev, the composition does not change significantly with the energy.

In the region between $10^{10}$ and $10^{11}$ ev, however, the fractional energy transfer to the electron component should vary considerably if, in accordance with the Bristol data, *K*-particles comprise about 50% of the total energy transferred to the meson component, and if the decay of $\pi_0$-mesons represents the only efficient transfer mechanism. In an attempt to check on these points, an experiment was performed in which showers were locally produced in a carbon block and their multiplicity recorded by a hodoscope arrangement before the electron component was fully developed. The shower electrons were counted with the help of a liquid scintillator placed under a lead absorber of suitable thickness. Further shielded Geiger counters served to select events in the desired energy range. The results of the experiment show that the fractional energy transfer to the electron component remains reasonably constant above about 20 Bev: that is, either the *K*-component does not carry off as much energy as the Bristol data would indicate, or else processes other than $\pi_0$-decay contribute appreciably to the formation of the electron component.

In a second series of experiments, structure and composition of air shower cores were investigated with an arrangement combining a hodoscope of over 100 counters with a multiple-plate cloud chamber. In this core region one might expect to find not only features related to the characteristics of the primary collision — in particular the original multiplicity — but also, since the core contains the highest particle energies, features revealing the energy dependence of the processes responsible for the development of the mixed cascades. By proper methods of triggering, it was again possible to classify the showers,

* The author wishes to acknowledge the competent and enthusiastic collaboration of his assistants: J. G. Askowith, F. E. Froehlich, H. L. Kasnitz, I. L. Kofsky, I. Nadelhaft, J. E. Rizzo, D. L. Stierwalt.

in the first experiment according to their size, and in the second according to their age. The results of the two experiments agree in the essentials which might be summarized as follows:

(1) The electron density near the shower core is considerably flatter than that demanded by cascade theory, and shows signs of an appreciable continuous "rejuvenation" of the electron cascade from the nucleonic cascade; (2) the nucleonic cascade extends to greater depths than those expected from earlier theories — in fact, it reaches its maximum development somewhat later than the electron cascade; and (3), frequency and composition of the penetrating component are practically independent of the shower energy, indicating that no striking changes occur in the essential cascade processes.

It is hoped that these experiments have fulfilled the purpose of clearing up some of the uncertainties which blocked further progress, and of shedding at least some light on some of the urgent questions concerning nuclear collisions at extremely high energies. Much more work will have to be done before we can confidently declare that we have solved the problems outlined in the beginning.

**Evidence for the existence of a superhyperon,** Y. EISENBERG, *Department of Physics, The Weizmann Institute of Science, Rehovot.* The known hyperons (particles of intermediate mass, between the proton and the deuteron) up to the present time are[1]:

$$\Lambda^0 \rightarrow p + \pi^- + 37 \text{ Mev}$$

$$\Lambda^{\pm} \rightarrow n + \pi^{\pm} + 120 \text{ Mev}$$

$$\Omega^- \rightarrow \Lambda^0 + \pi^- + 67 \text{ Mev}.$$

They may be regarded as "excited" nucleons, since a nucleon is always one of the decay products.

During the course of investigation of nuclear plates exposed to the primary cosmic radiation[2] the following event was found[3]. From a $5+11p$-type star, produced by a fast charged particle of energy about 30 Bev, a "gray" track $Y$ was emitted of velocity $\beta = v/c = 0.445$. After travelling 5,720 $\mu$, it suffers a 10° deflection. The part of the track after the deflection point will be called $K$. The mean scattering angle of track $Y$ was: $\bar{\alpha}(Y) = 0.072 \pm 0.016°/100\ \mu$. This, together with the ionization measurements, gives for the mass of $Y$: $M(Y) = 1640 \pm 360$ Mev ($3220 \pm 700\ m_e$).

Track $K$, after traversing 21,900 $\mu$, comes to rest and gets captured by one of the emulsion nuclei. The star which results from the capture of $K$ (see picture of the event in ref. 3) contains a fast meson; thus $K$ could not be a $\pi$-meson. Indeed, direct mass measurements of $K$ by: (a) scattering vs. residual range (constant sagitta method[4]), using both second and third differences, and (b) ionization vs. residual range, give for the mass of $K$: $M(K) \simeq 500$ Mev ($940 \pm 200\ m_e$). We consider, therefore, that the identification of $K$ as a heavy negative meson is established.

If $K$ and $Y$ are the same particle (the 10° deflection being due to nuclear or Coulomb scattering) it is expected that the scattering of $Y$ should be: $\bar{\alpha}_{calc} = 0.240°/100\ \mu$. Thus the difference between the observed and calculated scattering value of $Y$ is: $\bar{\alpha}_{calc} - \bar{\alpha}_{obs} = 0.168 \pm \pm .016°/100\ \mu$. The probability that such a difference is due to statistical fluctuations is negligible. The most probable interpretation of the whole event is that this is an example of a decay in flight of particle $Y^-$ into $K^-$. Supporting this hypothesis are the following two facts: (a) the 10° deflection, (b) the ionization of $Y$ is $1.10 \pm .04$ times the expected ionization of $K$.

There is no particle which is known to decay into a $K$-meson. Thus the above process must be either an alternate decay mode of a known particle, or a decay of a new unknown particle. The $Q$ of the decay: $Y^- \rightarrow K^-$ + neutral + $Q$, is about 5 Mev, no matter what the neutral particle is. Therefore, $M(Y) \simeq M(K) + M$ (neutral), and we obtain: $M(Y) = 1440$ Mev, if $Y^- \rightarrow K^-$ + neutron.

$$M(Y) = 1000 \text{ Mev, if } Y^- \rightarrow K^- + K^0.$$

The masses of the known hyperons are $M(\Lambda^-) = = 1200$ Mev, and $M(\Omega^-) = 1320$ Mev. Thus, the possibility of an alternate two-body mode of decay of a known hyperon is ruled out. By the above argument, we also exclude: $Y^- \equiv \Lambda^- \rightarrow K^- + n +$ neutral + $Q$ (3-body decay, in which case the $Q$ is unknown). The decay scheme: $Y^- \equiv \Lambda^- \rightarrow K^- + K^0$ (or $\pi^0$) + neutral + $Q$ is excluded, since it will require the annihilation of a nucleon in the decay process, which we do not like to believe possible.

On the assumption that $Y^-$ is a new hyperon we obtain:

if: $Y^- \rightarrow K^- + n$, then $M(Y^-) = 1440$ Mev $2830\ m_e$

if: $Y^- \rightarrow K^- + \Lambda^0$, then $M(Y^-) = 1610$ Mev $= 3160\ m_e$

These values agree with the direct mass value of $Y^-$, $1640 \pm 360$ Mev. An event which supports the existence of $Y^-$ has recently been discovered by Fry[2] et al. The time that $Y^-$ lived is $0.43 \times 10^{-10}$ sec, the same order of magnitude as that of the $\Lambda$ particles.

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**Some problems connected with elementary particles,** G. YEKUTIELI, *The Weizmann Institute of Science, Rehovot.* The heavy unstable particles fall into two groups of mass: the hyperon group, which includes all unstable particles heavier than the proton which decay into a nucleon and some other particle, and the *K*-particle group, which includes particles with mass between that of the pion and that of the proton which decay into a light meson, $\pi$ or $\mu$, and one or more light particles.

Here we shall concentrate on the *K*-particle group. There is quite good experimental evidence for the existence of several *K*-particles of different modes of decay. This experimental evidence is reviewed below in an attempt to find out how many different *K*-particles are known so far and what are their different decay schemes.

The best known *K*-particles, the $\tau$ and the $\theta^0$, have the same mass within the experimental error: $M_\tau = 965.5 \pm 0.7$ $m_e$ and $M\theta = 966 \pm 10$ $m_e$. Their decay schemes are $\tau^\pm \rightarrow \pi^\pm + \pi^+ + \pi^-$ + 75 Mev and $\theta^0 \rightarrow \pi^+ + \pi^-$ + 214 Mev. Now if we assume that $\tau = \theta$, and remember that the $\pi$-meson has a negative parity, we shall find that the wave function of the two pions originating in the $\theta^0$ decay will have opposite parity to that of the wave function of the three pions originating in the $\tau$ decay. This means that if $\theta = \tau$ they cannot be of zero spin. Dalitz, by analyzing the energy distribution of the 3 pions originating in decay, came to the conclusion that the most likely value for the spin of the $\tau$ is zero. Thus the $\theta$ and the $\tau$ are different particles and they are not charged multiples of the same particle.

There is another charged *K*-particle, the $K_{\pi_2}$, that could be the charged counter particle of the $\theta^0$. The $K_{\pi_2}$ is one case of the sub-group, $K \rightarrow$ one light particle. As for the identity of the light particle: there is good evidence for the decays $K \rightarrow \pi$ meson and $K \rightarrow \mu$ meson, and only one suspected case of $K \rightarrow$ electron[1]. There is strong evidence that the $K \rightarrow \pi$ decay particle is a mixture of two different particles[2], $K_{\pi_2} = \theta^\pm \rightarrow \pi^+ + \pi^-$ + 220 Mev, and $K_{\pi_3} = \tau \rightarrow \pi^\pm + 2\pi^0$ + 75 Mev. Again in the case of $K \rightarrow \mu$ there are two modes of decay: a two body decay[2] $K_{\mu_2} \rightarrow \mu + \nu$ and a three body decay $K_{\mu_3} \rightarrow \mu + \nu + \nu$. The $K_{\mu_2}$ is a Boson and could be a different mode of decay of the $\tau$ or the $\theta$, however it appears as if the mass of the $K_{\mu_2}$ were somewhat lower, $K_{\mu_2} = 920 \pm 20$[3] and it could be a different particle altogether.

Thus, in order to explain the experimental observations of the *K*-particle, we must invoke at least the existence of one Fermian *K*-particle that may have two modes of decay $K_F \rightarrow \mu + \nu + \nu$ or $K_F \rightarrow e + \nu + \nu$, and two Bosons $\tau \rightarrow 3\pi$ and $\theta \rightarrow 2\pi$, and maybe a third Boson $K_{\mu_2} \rightarrow \mu + \nu$ which could be an alternative mode of decay of one of the above mentioned two Bosons.

1. In the 5th Rochester conference 6 more definite cases of $K \rightarrow$ electron were reported, 2 from each of the laboratories in Bristol, Berkeley and Rochester.
2. Very good evidence in support of the decay schemes $K_{\pi_2} \rightarrow \pi^+ + \pi^-$ + 222 Mev and $K_{\mu_2} \rightarrow \mu + \nu$ was presented in the 5th Rochester conference and the existence of these particles is beyond doubt.
3. The new value given at the 5th Rochester conference is $M_{K_\mu} = 942 \pm 20\ m_e$.

**Heavy primaries in the cosmic radiation,** Y. EISENBERG, *The Weizmann Institute of Science, Department of Physics, Rehovot.* In 1948 Freier et al.[1] found that, besides protons, heavier ions are also present in the primary cosmic radiation. They observed tracks of multiply charged heavy ions in photographic emulsions exposed above 90,000 feet in a balloon flight. Recent experiments by Peters [2–5] and others, using emulsions, have shown that heavy nuclei contribute very largely to cosmic ray phenomena, since they carry to the top of the atmosphere about 30—35% of the incoming nucleons. A review article by Peters[4] summarizes the information that was available on the subject until the early part of 1952.

Below is discussed the information that can be derived from heavy primary research.

The instrument which is often used in this kind of investigation is the "Emulsion Cloud Chamber"[6]. It consists of photographic plates packed inbetween some absorber (lead, brass etc.) in such a way that the tracks of the primaries could be followed from plate to plate, and the results of the interaction of the primary nuclei in the absorber could be studied in great detail[7].

Charge measurements are made by grain counting and by δ-ray counting[5,6]. Both are proportional to the square of the ion charges and to the velocity:

$N(\delta) = Z^2 \cdot F(\beta)$, $N(g) = Z^2 \cdot G(\beta)$, where: $\beta = v/c$.

A. *Origin of cosmic rays.* The discovery of heavy ions among the cosmic rays primaries changed appreciably the theories of origin of cosmic rays[8]. It becomes no longer possible for the primary radiation to travel long distances in the galaxy before reaching us, since the heavy elements will be destroyed by their nuclear collisions with the interstellar hydrogen gas. On the other hand, the isotropy of the primary cosmic radiation[9] requires that either the radiation travel for a long time in the galaxy, or else that a strong "mixing" magnetic field exist in the galaxy. It is known that Li—Be—B are not abundant in the universe. They may be created in nuclear collisions. The ratio of, say, Li, Be, B to C, N, O present in the primary radiation will indicate how much matter has the primary radiation traversed before reaching us. Contradictory evidence exists in the literature[3,5] on the subject, but recent measurements[10] seem to indicate that the above ratio is ~0.5.

The energy spectrum was measured and found to be[6,7]: $N(>E) \sim (1+E)^{-1.3}$, where $N(>E)$ is the number of particles of energy greater than $E$. ($E$ is measured in Bev per nucleon). For details on the energy determination methods see ref. 6 and 7. It was also found[7] that the observed spectrum agrees with the assumption that charged particles do not enter the earth's field with energies below the predicted "cut-off" energy.

The relative abundance of the charge group, $A : Z = 12 - 17$ and $B : Z > 18$ is believed[11] to be, based on astronomical data, about one. The value determined from the cosmic rays measurements[7] is: $A/B = 2.1$.

B. *Nuclear physics.* The fragmentation of the heavy nuclei during the collisions with the target nuclei has been studied in great detail[7,10] The process can be regarded as (a) actual "cutting" of part of the nucleus, and (b) subsequent evaporation of nucleons. It is possible to calculate it in the extreme relativistic case[7], where the incoming nuclei have energies $E \gg MC^2$. Experimentally, the observed fragmentation is in good agreement with the calculations.

The mean-free-path of a nucleus $A$ in target of atomic number $A'$ is given by:

$$\lambda_A(A') = [A'/(\sigma_A(A') \cdot N)] \text{ g/cm}^2,$$

where $N$ is the Avogadro number, and $\sigma_A(A')$ is the cross-section for interaction of $A$ in the target $A'$. If the cross-section is geometric, one obtains: $\sigma_A(A') = \pi(R_A + R_{A'})^2 = R_0^2(A^{1/3} + A'^{1/3})^2$, since $R_A$ can be written as $R_A = R_0 \cdot A^{1/3}$. Thus, measurements of the mean-free-path will give a value for $R_0$, the nuclear radius. Early measurements of Kaplon[5] et al. have shown that it is impossible to fit the data to the values of $R_0$ then widely accepted ($R_0 = 1.45 \times 10^{-13}$ cm); the best fit to the data was obtained by:

$$\sigma = \pi(R_1 + R_2 - 2\Delta R)^2$$
$$R = R_0 A^{1/3}, \quad R_0 = 1.45 \times 10^{-13} \text{ cm}$$

where $\Delta R$ is a constant, $\Delta R = 1.0 \times 10^{-13}$ cm.

Recent measurements of Noon[10] and Kaplon require: $\Delta R = 0.85 \cdot 10^{-13}$ cm. Eisenberg[7] has shown that all the existing experimental data can be fitted quite well to the theory if the value $R_0 = 1.3 \times 10^{-13}$ cm is used, and the transparency of nuclear matter is taken into account. The value which he used for the mean free path of a nucleon inside nuclear matter is: $\lambda = 5 \cdot 10^{-13}$ cm.[7] The value $R_0 = 1.2 \cdot 10^{-13}$ cm is now quite widely accepted[12].

The neutron extension in the nucleus can be detected by observing stars in the emulsion, produced by heavy primaries, in which there is no apparent change in the charge[13]. The recent work of Noon[10] and Kaplon reports such events, but no actual numbers for the extension are given.

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**Charge distribution of an assembly of pions,** Yehudah Yeivin, *The Weizmann Institute of Science, Rehovot.* It has been long known that at sea level positively charged penetrating cosmic ray particles predominate over the negatively charged ones. These particles are mostly muons (μ-mesons); hence the phenomenon is referred to

as the positive excess of muons. This positive excess is believed to be closely related to the preponderance of positively charged primaries from which the muons are generated through the pion ($\pi$-meson) intermediate stage. Thus the positive excess of the muons is a consequence of the positive excess of the pions. To explain this phenomenon one has to investigate the charge distribution of pions produced in nuclear interactions, which we assume to be charge independent. The first problem which arises in this connection is to find the charge distribution in a system of pions, characterized by a total isotopic spin $T$ and a total charge $T_0 = M$.

Let us consider a system of $n$ pions, in which the average number of positive particles is denoted by $\pi^+$, that of neutral particles by $\pi^0$, and that of negative ones by $\pi^-$. Then

$$\pi^+ + \pi^0 + \pi^- = n, \quad \pi^+ - \pi^- = M. \qquad (1)$$

It is therefore sufficient to find just one of these three functions. As we shall see, it is convenient to calculate $\pi^0$, or rather a simple function of it, namely

$$X = n - 3\pi^0. \qquad (2)$$

This function measures a certain asymmetry existent in the state of our system of pions. In a symmetric state two thirds of the pions are charged and a third is neutral, so that $X = O$. If $X$ is positive or negative ($X \gtrless 0$) then $\pi^0 \lesssim n/3$. In all problems related to pion production it is generally assumed that $X=0$. Our purpose is to find to what extent this approximation is justified.

To show why $X$ is suitable for calculation, let $\vec{\tau}_j$ be the isotopic spin of the $j$-th pion. Then

$$\sum_j [\vec{\tau}_j \cdot \vec{\tau}_j]^2_0 \sim \sum_j (3\tau_{j0}^2 - \tau_j^2) \qquad (3)$$

(this is similar to $[Y^1 \cdot Y^1]^2_0 \sim Y^2_0 \sim 3\cos^2\theta - 1$).

Now, $\tau_j^2 = \tau_j(\tau_j + 1) = 2$, and $\sum \tau_{j0}^2$ measures $\pi^+ + \pi^-$, therefore our tensorial product is proportional to

$$3(\pi^+ + \pi^-) - 2n = 3(n - \pi^0) - 2n = n - 3\pi^0 = X. \qquad (4)$$

Thus $X$ is seen to be the zeroth component of an irreducible tensor operator of order 2.

Our aim now is to calculate the average value of $X$ in a state $(TM)$ of the pions. But these states are generally degenerate. Their multiplicity is an easily calculated function[1] of $n$ and $T$, which we shall denote by $g_n(T)$. If the single states are $|\alpha TM)$, then, *assuming* that they are all equally probable and add up with random phases, we have to calculate

$$X(TM) = [1/g(T)] \sum_\alpha (\alpha TM \mid X \mid \alpha TM). \qquad (5)$$

Since $X$ is the zeroth component of a tensor operator of order 2, then, according to the Wigner-Eckart Theorem, it equals[2]

$$\frac{(-)^{T-M}}{g(T)} \begin{pmatrix} T & 2 & T \\ -M & 0 & M \end{pmatrix} \sum_\alpha (\alpha T \| X \| \alpha T) = \frac{(-)^{T-M}}{g(T)} \begin{pmatrix} T & 2 & T \\ -M & 0 & M \end{pmatrix} R(T). \qquad (6)$$

Our problem is thus reduced to calculating the $R$'s. This is quite simple with the help of Slater's Sum Method, for summing $g(T)X(TM)$ over $T$ we get

$$\sum_{T=M}^{n} g(T)\, X(TM) = X(M) f(M) = \sum_{T=M}^{n} (-)^{T-M} \begin{pmatrix} T & 2 & T \\ -M & 0 & M \end{pmatrix} R(T), \qquad (7)$$

where $X(M)$ is the average of $X$ over *all* possible states of total charge $M$, while $f(M)$ is the number of these states, equalling

$$\sum_{T=M}^{n} g(T).$$

Knowing $X(M)$, the $f$'s, and Wigner coefficients, we can calculate the $R$'s. Starting from $M = n$ we get[3]

$$R(n) = \frac{X(n) f(n)}{\begin{pmatrix} n & 2 & n \\ -n & 0 & n \end{pmatrix}} = \sqrt{\frac{n(n+1)(2n+1)(2n+3)}{2n-1}} \qquad (8)$$

and so on.

To illustrate our results, Table I gives the difference between the actual percentage of $\pi^0$ and 33%, which is the percentage of neutral pions in a symmetric state, as a function of $n$ and $T$, for $M = 0$.

TABLE I

$100\,\pi^0/n - 33$ $(M = 0)$

| $n$ | $T=0$ | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | 0 | 67 | — | — | — | — |
| 2 | 0 | −33 | 33 | — | — | — |
| 3 | 0 | 13 | 0 | 27 | — | — |
| 4 | 0 | −3.3 | 7.1 | 6.7 | 24 | — |
| 5 | 0 | 2.7 | 1.9 | 7.1 | 9.5 | 22 |

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$$\begin{pmatrix} a & b & c \\ \alpha & \beta & \gamma \end{pmatrix} = \frac{(-)^{a-b-\gamma}}{\sqrt{2c+1}} (a\,\alpha\, b\,\beta \mid a\, b\, c - \gamma)$$

3. Because $f(n)=1$, $X(n)=n$, and

$$\begin{pmatrix} T & 2 & T \\ -M & 0 & M \end{pmatrix} = \frac{(-)^{T-M}[3M^2 - T(T+1)]}{\sqrt{T(T+1)(2T-1)(2T+1)(2T+3)}}$$

NOTE ADDED IN PROOF

The author is grateful to Prof. G. Racah for pointing out to him that a *closed* formula could be derived for the $R(T)$'s:

$$R(T) = n\sqrt{\frac{2T+1}{T(T+1)(2T-1)(2T+3)}}$$
$$\times [(T+1)(2T+3)\, g_{n-1}(T-1) - (2T-1)\,(2T+3) g_{n-1}(T) + T\,(2T-1) g_{n-1}(T+1)]$$

A proof of this formula will be given elsewhere.

## SYMPOSIUM ON THE SOLID STATE

**Some aspects of transistor physics,** H. K. HENISCH, *Reading University, Reading, England.* Considering the conditions in semi-conducting filaments, it is always possible to define the current composition ratio $\gamma_0$ for quasi-equilibrium, i.e. the fraction of the total current carried by minority carriers in the bulk material. It is further possible to envisage contacts at which the current composition ratio $\gamma$ differs from $\gamma_0$. Accordingly we distinguish between four types of departures from electronic equilibrium, namely ($\gamma_1 > \gamma_0$) *injection* and ($\gamma_1 < \gamma_0$) *exclusion* at and near the contact biased in the forward direction and ($\gamma_2 > \gamma_0$) *extraction* and ($\gamma_2 < \gamma_0$) *accumulation* at the contact biased in the reverse direction. All these phenomena give rise to changes of filament resistance, and their establishment is governed by a relaxation time constant. A filament with an injecting contact thus behaves inductively and a filament with an excluding contact capacitively. The phenomena may in practice overlap in pairs.

The relaxation time is governed by the surface as well as volume recombination of charge carriers, of which surface recombination is a subject of particular practical and theoretical interest. One of the methods of studying it is by measuring the steady-state photo-conductance of a semiconducting plate under various conditions. The photo-conductance depends on an effective carrier life-time and, if the bulk life-time is known, a surface life-time can be evaluated. Good agreement between theory and experiment has been obtained. It is also of interest to study the behaviour of surface recombination under various externally (capacitively) applied electric fields. By means of such fields, surface recombination can be enhanced or inhibited depending on the polarity of the applied field. The results obtained in this way suggest a breakdown of the positive hole concept in the special context of surface recombination phenomena.

**Electronic band structure of germanium,** S. MEIBOOM, *The Weizmann Institute of Science, Rehovot.* In semiconductors the parts of the electronic energy bands of main interest are the top of the valence band and the bottom of the conduction band, as these parts only contribute to the electric conduction. In the neighbourhood of a non-degenerate energy extremum, the energy can be approximated by a quadratic function of the crystal momentum $P$, higher order terms in the expansion of the energy being neglected. We have accordingly the following possible models:

1. The top (or bottom) of the band is not degenerate. In a crystal with cubic symmetry the constant energy surfaces can then be approximated by a set of spheres around the centre of the Brillouin zone.
2. The top (or bottom) of the band is degenerate and the extrema of the different branches are at different values of $P$. The energy surfaces will form sets of ellipsoids, so arranged in the Brillouin zone as to fulfil the cubic symmetry of the germanium crystal. In this case, the two simplest models are:
   a) six sets of ellipsoids of revolution, with their main axes directed along the [100] directions of the reciprocal lattice.
   b) eight sets of ellipsoids, with the main axes along the [111] directions of the reciprocal lattice.
3. The top (or bottom) of the band is degenerate at $P = 0$. The extremum is then a singular point and the energy surfaces can no longer be approximated by spherical surfaces[1].

Information as to the actual structure of the energy bands can be obtained from theoretical calculations and from experimental evidence. For the germanium crystal theoretical calculations have been carried out by Herman[2]. His results are that case 3 applies to the valence band and case 2 to the conduction band, but the results are not accurate enough to decide whether 2a or 2b applies.

The most direct experimental evidence as to the structure of the energy bands is obtained from measurements of the cyclotron resonance[3]. These results fit the assumption of case 3 for the valence band and case 2b for the conduction band.

Other experimental evidence can be obtained from measurements of the magnetoresistance effects[4], which can be anisotropic in cubic crystals. The measured magnetoresistance coefficients in single crystals of *n*-germanium are in excellent agreement with the values calculated assuming case 2b for the conduction band, while the calculated values assuming other cases are in complete disagreement with the experimental data. However, the measured magnetoresistance coefficients in *p*-germanium cannot be explained by any of the above models for the valence band.

There is also other evidence of abnormal behaviour of *p*-germanium in contrast to *n*-germanium: the lattice mobility depends on temperature accordingly to $T^{-2.3}$, instead of $T^{-1.5}$ as predicted by the simple theory[5]; the ratio of Hall-to drift-mobility is temperature dependent[5]; the infrared spectrum shows a number of absorption bands at wavelengths longer than the absorption edge[6]. This behaviour of *p*-germanium can be explained by assuming two branches of the valence band as in model 3 above, but separated by a small energy gap (about 0.06 ev) at $P = 0$. Calculations based on such a model show that the gradual filling of the lower branch with holes with rising temperatures could cause the abnormal temperature behaviour. However, it is theoretically not clear what interaction could cause the splitting of the two branches.

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**Mobility and diffusion constant of carriers in germanium,** A. Many, *Department of Physics, The Hebrew University of Jerusalem.*

*Introduction*

One of the most basic relationships in semiconductor physics is that expressing the hole and electron flow in a semiconductor in terms of the electric field, carrier concentrations and mobilities[1]:

$$J_p = e\mu_p pE - eD_p \operatorname{grad} p$$
$$J_n = e\mu_n nE + eD_n \operatorname{grad} n \qquad (1)$$

where $E$ is the electric field, $J_p$ and $J_n$ the hole and electron current densities, $p$ and $n$ the free hole and electron concentrations, $\mu_p$ and $\mu_n$ the hole and electron mobilities, and $D_p$ and $D_n$ the diffusion constants.

The first terms represent the field currents, the mobilities being the average carrier velocities per unit field in the direction of the field. We shall only be concerned with low field mobilities, i.e. in cases in which the applied field is small enough so that the energy gain of the carriers from the field is small compared with their thermal energy, and the Maxwell-Boltzmann distribution is not appreciably disturbed by the field.

The second terms in Equs. (1) represent diffusion currents which are present whenever unhomogeneous density concentrations are present. These currents result from the tendency of carriers to diffuse from regions of higher to lower concentrations. The diffusion constants are related to the respective mobilities by the well known Einstein relationship[1]:

$$\mu_p = eD_p / kT$$
$$\mu_n = eD_n / kT \qquad (2)$$

In homogeneous media, at equilibrium, the diffusion currents reduce to zero, and we obtain the more familiar expression

$$J = J_p + J_n = \sigma E$$
$$\text{where } \sigma = e(\mu_p p + \mu_n n) \qquad (3)$$

It is thus seen that the mobilities can be either measured directly by measuring the average carrier velocity in an applied electrical field, or by measuring the diffusion constants in situations where non-uniform carrier concentrations are present. We shall briefly review the various methods of mobility measurements and then give a fuller account of the method used here for measuring diffusion constants, and the results obtained.

*Mobility*

There are several operational definitions of mobility corresponding to the various experimental methods of measurement. (a) *The conductivity mobility* $\mu_\sigma$ is the mobility entering Equ. (3), and can be measured by adding known amounts of impurities which thus add known numbers of carriers; from these known numbers and the measured conductivity, $\mu_\sigma$ can be determined. (b) *The Hall mobility* $\mu_H$ as determined from Hall effect measurements. (c) *The drift*

*mobility* $\mu_d$ as measured by the Haynes-Shockley method[2]. In this experiment, minority carriers are injected at one point of a filament in which a strong electric field is present. The injected carriers drift down the filament and are detected at a second point along the filament. The drift mobility is then obtained from the drift velocity, which is equal to the distance between the points, divided by the transit time.

If the crystal contains trapping levels capable of binding carriers tightly enough so that they are free to move only a fraction of the time, then the drift mobility would be only a fraction of the (d) *microscopic mobility* $\mu_m$, which is defined as the drift mobility of untrapped carriers.

It should be pointed out that in the first two experiments the mobilities are measured on crystals with undisturbed equilibrium concentrations of carriers. The crystals used are usually strongly *n*-type or *p*-type so that the contributions of the minority carriers are negligible. In the third type of experiments, on the other hand, the carrier concentrations are locally disturbed, and the drift velocity of the injected *minority carriers* is measured.

The comparison of the experimental results for the various mobilities just defined, both at room temperature and over a wide range of temperatures, furnishes a great deal of information on the conduction mechanism. Only a few points will be mentioned here.

(1) At low temperatures appreciable trapping, especially of holes, takes place both at the surface and in the bulk, and deviations of $\mu_d$ from $\mu_m$ occur. Such effects were observed by Fan et al.[3], Lawrance[4], and the author[5], and furnish a useful tool for investigating trap densities and their energy depth.

(2) The variation of mobility with temperature furnishes information on the thermal, impurity and dislocation scattering; e.g. from the impurity scattering, effective masses of the carriers were derived by Debye and Conwell[6].

(3) From the measured ratio $\mu_H/\mu_d$ one can obtain information on the band structure[7]. For instance, for a Maxwell-Boltzmann statistics and spherical energy surfaces in the Brillouin zone, this ratio should be equal to $3\pi/8$[(1)].

At room temperature in germanium, $\mu_\sigma$, $\mu_d$ and $\mu_m$ are very nearly equal.

### *Diffusion constant*

As has been mentioned previously, drift mobilities can also be obtained from the measurement of carrier diffusion constants. These were obtained, in the method used here, by measuring the injected carrier life time in rectangular filaments with rough surfaces[5]. Although this method is superficially similar to that of Haynes and Stockley, the two are basically different. In the latter the mobility is obtained from the drift velocity down the filament, while here, the diffusion constant of the carriers *perpendicular* to the direction of drift is measured. When excess carriers are injected into such a filament, their effective lifetime $\tau$ is given by[1]

$$1/\tau = 1/\tau_b + (\pi^2\ D/4)\,(1/B^2 + 1/C^2) \qquad (4)$$

where $\tau_b$ is the bulk lifetime, $D$ the diffusion constant and $2B$ x $2C$ the filament cross section dimensions. Thus $D$ can be obtained from the measurement of $\tau$ and the mobility is then derived from (2).

The use of the bridge method for lifetime measurements, described previously[8], gives high accuracy in the measured diffusion constants and hence in the calculated mobility values. The measurements were carried out at room temperature, and from 400°K down to liquid air. They included both *p*-type and *n*-type Ge filaments, in order to obtain the electron and hole mobilities respectively. The hole and electron mobilities at $T = 300$°K were determined as $2000 \pm 80$ and $4450 \pm 150$ cm²/volt-sec, and their temperature dependence as $T^{-2.3}$ and $T^{-2.0}$, respectively. The results for holes are in good agreement with the most recent values obtained by Prince[9] using a modification of the Haynes-Shockley method. For electrons, however, our results are appreciably different (4450 compared to 3900 at $T = 300$°K, and a temperature dependence of $T^{-2.0}$ compared to $T^{-1.7}$). This difference cannot be accounted for by the margin of error in the two results. It is believed that the method of measurement employed here has an important advantage over that of Haynes—Shockley. In the latter the injected carriers drift down a thin filament and may thus be affected by surface effects, such as trapping. With the present method, however, the measurement is concerned only with the carriers diffusing *in the bulk* of the filament, the surface merely serving to remove the carriers as soon as they reach it. Thus surface effects are completely eliminated.

The measured temperature dependence of the diffusion constants also yielded information on transport phenomena in near-intrinsic and intrinsic ranges (ambipolar flow). At sufficiently high temperatures (in the filaments used, 300-350°K) the variation of diffusion constant with

temperature ceases to obey the above mentioned power laws. This is due to the fact that in this range the material undergoes a change from extrinsic to intrinsic conditions. The diffusion of excess carriers is no longer characterized by that of the minority carriers alone, but is also affected by the diffusion of the majority carriers. The resulting effective diffusion constant, appropriate for Equ. (4) in this case, was calculated by Van Roosbroeck[10] to be

$$D_{pn} = (p + n) / (n/D_p + p/D_n) \qquad (5)$$

where $p$ and $n$ are the hole and electron concentrations in the filaments under discussion. For $p \ll n$, for example, $D_{pn}$ reduces to $D_p$ which is characteristic of hole flow in extrinsic $n$-type filament. At high temperatures, $p$ may be comparable to $n$ and the value $D_{pn}$ should then be used. The experimental results at this range of temperatures, for both hole and electron flow, were compared with the theoretical formula (5), and the agreement was found to be satisfactory.

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**Growth features on diamond surfaces,** A. Halperin, *Department of Physics, The Hebrew University of Jerusalem.* The trigons are very common on octahedral natural diamond faces. These are equilateral triangular pits on the surface, quite different from the etch figures on these faces, and it is now evident that they are growth features. On some diamonds almost no trigons can be observed. Usually, however, many of them are present on the octahedral faces, their density varying up to $10^7$ per cm$^2$. A phase contrast photograph showing trigons on a face of a diamond is given in Figure 1. The small dark triangular features are the trigons. They are distributed along the terraces of the growth pyramid seen in the figure.

A theory was proposed to explain the formation of the trigons during the process of growth of the crystal[1]. To account for the characteristics of the trigons, it was assumed that defects in the lattice accumulate to form imperfect steps on the growing surface. It was further shown that, under certain conditions, these imperfect steps should not retard the growth, and might even serve as nucleation centres for growth. Under other conditions (below a critical temperature) growth should, however, be arrested along the imperfect steps, when trigons start to be formed.

A few growth features observed on diamond faces, which seem to support the above assumptions, are described below.

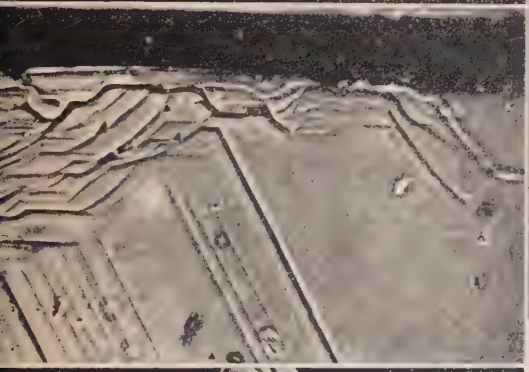
Figure 2 shows a misfit-boundary on the crystal face (the dark region towards the top in the photograph). These boundaries are generally believed to originate in imperfect steps formed during the process of growth. In the case shown in Figure 2, many growth layers emerge from this boundary.

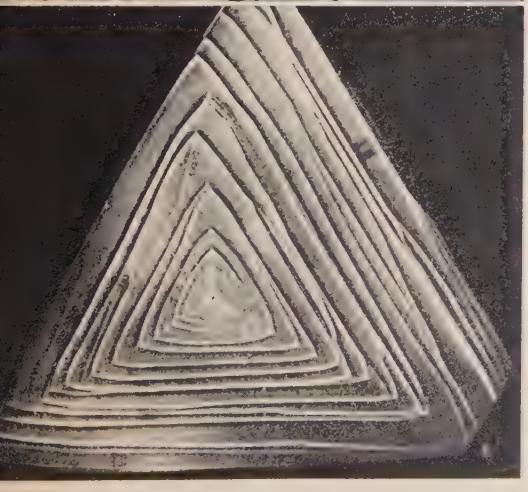
Figure 3 shows a growth pyramid which covers the whole face of a crystal. In this case the source of the growth layers is a single trigon in the centre.

In Figures 4 and 5 two types of disturbance-lines are shown. In both cases the disturbance occurred while the crystal was still growing and in both growth, continuing after the disturbance, resulted in a high concentration of trigons in strong correlation with these lines.

In Figure 4 the trigons describe a line just parallel to a misfit boundary on the face. The explanation of the formation of these trigons is as follows: It is assumed that in the history of the growing crystal an imperfect step was formed on a lower level, whose traces on the completed crystal are given by a line just along the centres of the row of trigons. This imperfect step divided the growing face into two parts, growth at the lower part being delayed slightly. With the advance of growth, the upper part developed the misfit boundary with the layers bunched towards the edge forming a slope along this boundary. At the same time this boundary served also as a centre for nucleation for the growing layers in the lower part, and, when more layers grew in this way, they resulted in a comparatively high concentration of trigons along the line of disturbance, which might be expected by the above assumptions.

Figure 5 shows a slip line (the horizontal line) with trigons concentrated along it. The vertical dark line is a profile line[2], on which a deviation to the right corresponds to a step down on the surface. The step height at the slip line is in this case slightly more than half a micron. This phenomenon was investigated fully[3]. The investigation was carried out on some 50 lines revealed on one diamond, and the conclusions were that they are the result of growth on slip lines. Since





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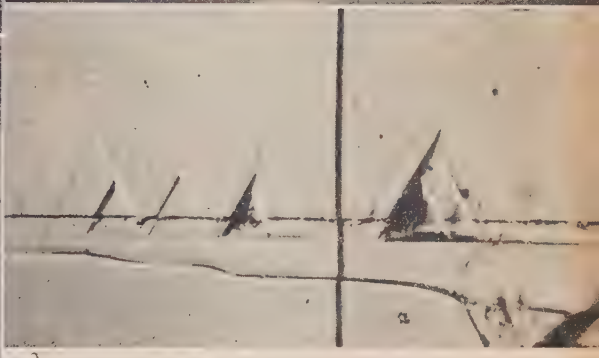

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Figure 1

A growth pyramid with trigons on an octahedral face of a diamond. Phase contrast illumination (x80).

Figure 2

Growth layers emerging from a misfit boundary on the face. Phase contrast (x260).

Figure 3

A growth pyramid centred on a trigon. Phase contrast (x80).

Figure 4

A misfit boundary with trigons arranged in parallel to it. Phase contrast (x550).

Figure 5

A slip line (horizontal line) with trigons "strung" along it. The vertical line is a profile line. Oblique illumination (x800).

this investigation was carried out, such slip lines were observed on more diamonds, Figure 5 being one of them.

We may conclude from the above that 1) imperfect steps *and trigons* on diamond faces act as centres of growth, and that (2) disturbances on the growing crystal surface result in high concentrations of trigons. Thus, the above described growth features support the main assumptions of the mentioned theory of the formation of trigons.

ACKNOWLEDGMENTS

It is a pleasure for me to thank Professor Tolansky for his continuous interest in the course of this work and for the facilities of his laboratory at Royal Halloway College, The University of London, where most of this experimental work was carried out. I wish also to thank the Humanitarian Trust and the Friends of the Hebrew University in London for a grant.

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**Paramagnetic resonance in the solid state,** W. Low, *Department of Physics, The Hebrew University of Jerusalem.* Paramagnetic substances have permanent magnetic dipoles of electronic origin. The magnetic properties of such substances are due in part to the contribution to magnetism from the orbital motion of the electron and in part to the intrinsic spin of the electron. A permanent magnetic moment occurs whenever there are atoms or ions with incomplete shells. This restricts paramagnetic substances to the transition elements: the iron, rare earth, palladium, platinum, and uranium groups.

There exists another large group of paramagnetic substances, which arises from imperfections in crystal lattices. These defects may be due to the natural or artificial incorporation of paramagnetic impurities or to the irradiation of samples with ultraviolet rays, X-rays, electrons, or neutrons. These may give rise to unpaired electrons and hence to paramagnetism.

If a paramagnetic ion is placed in a magnetic field, the energy levels are split. The transition frequency between the Zeeman levels is given by $\nu = g\beta H/h = 1.40 \times 10^6\, gH$ cycles. In a field of about 3500 gauss this corresponds to a wavelength of 3 cm with a $g$ factor of 2.

In a paramagnetic solid the interatomic forces acting on the ion are very strong. These forces can be approximately represented by an electrostatic potential due to the diamagnetic neighbours. In the $3d$ group this field is so strong as to lock the orbital motion to the field of the environment. The orbital motion, therefore, does not contribute directly to the magnetic moment but only indirectly by means of the spin-orbit coupling. The orbital component is an anisotropic quantity and will depend on the orientation of the crystalline electric axes with respect to the external magnetic field. The $g$ factor, therefore, will not be that of the free ion or that of the free spin but a tensor quantity. The inferences of this are as follows: a) the spectrum is very dependent on the local electric symmetry, b) each paramagnetic substance will show its own spectrum, c) different valencies will show different spectra, d) each ion per unit cell will have its own spectrum. The paramagnetic resonance spectrum is, therefore, a very important tool in the study of local electric field symmetry. It can be used to great advantage for the study of mineralogical problems and for the detection and identification of the location and valence of paramagnetic impurities.

$Mn^{2+}$ is an ideal tracer for local electric field symmetries. It has 5 $3d$ electrons with a ground state of $^6S_{5/2}$. A combination of tetragonal or trigonal symmetry and spin-spin interaction causes considerable electronic splitting (fine structure). A pronounced hyperfine structure of 6 lines is observed in addition. This is due to the configurational interaction in which a $3s$ electron is promoted to the $4s$ state[1]. This theory seems to account for the spectrum of the Tutton salt $K_2Mn\,(SO_4)_2 \cdot 6H_2O$, in which Mn is diluted to about 1 part in 200 by Zn. In the cubic SrS, SrSe substances the electronic splitting is very small and the spectrum nearly isotropic. In this powdered substance the $\frac{1}{2} \rightarrow \frac{1}{2}$ transition gives rise to 6 symmetrical hyperfine lines. The other transitions are smeared out in a powdered specimen. Actually we observed 12 lines, probably 6 lines due to the substitution of Mn in SrS and 6 due to SrSe. This seems to indicate that the configurational interaction is influenced to some extent by the environmental field[2].

An example of a spectrum in the $4f$ group is $Eu^{2+}$ in the phosphor SrS : Eu, Sm. The ground state is $^8S_{7/2}$. The $g$ factor of 1.991 as well as the narrow lines indicate a small electronic splitting due to the cubic field. A hyperfine structure of 12 lines confirms the spins of the two isotopes as $^5/_2$ and gives the ratio of their magnetic moments as 2.235. The hyperfine structure is probably due to configurational interaction but one of much smaller magnitude than in the $3d$ group[3].

An example of induced paramagnetism is polythene irradiated by neutrons[4]. These specimens show a "Christmas tree" structure with one central component and three components symmetrical on each side with intensity ratio of 100: 74: 44: 15 and a half width at half power of about 20 gauss. This spectrum (similar to the spectrum due to $F$ centres[5]) can be explained as due to the interaction of the unpaired electrons with the nuclear magnetic moments of the surrounding protons. The results are compatible with either 6 or 8 surrounding hydrogen atoms in which the electron spends 2.5—3.0% of its time on each of the respective hydrogen atoms.

Much of the information we now have on solids is macroscopic and mainly on electrons in the conduction band. Paramagnetic resonance sees the deeper lying electrons. The interaction of these electrons with the environment as expressed in the $g$ factor gives a great deal of information regarding the local electric field, the type of bonding, and important nuclear data.

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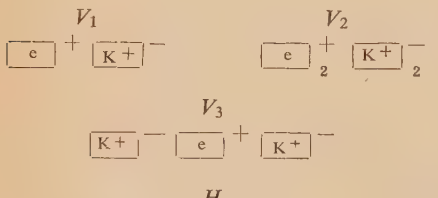
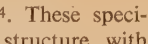
**The constitution of $V$-centres in alkali halides,** A. Glasner, *Department of Inorganic and Analytical Chemistry, The Hebrew University of Jerusalem.* The nature of $F$- and $V$-centres in alkali halides, and the various methods by which they are produced, were briefly described. An extensive study of the electron defect centres ($V$) has begun only very recently. Models for the constitution of the most prominent of these centres, as proposed by Seitz[1], are:




They are shown here by a set of symbols (to be published elsewhere) in which any integral entity absent from the lattice is enclosed in squares [ ]. Other symbols are those accepted in conventional chemical formulae. For example,



stands for a pair of vacancies with the indicated effective charges, and  designates a hole, namely a halogen atom situated at a lattice point normally occupied by a halogen ion.

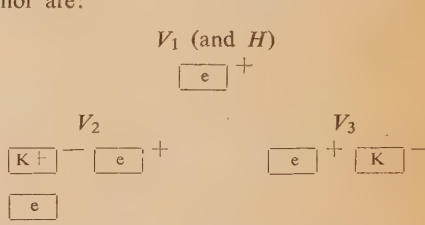
To these models the following objections were raised:

1. The thermal instability of $V_1$-centres requires that the bond between the hole and the cation vacancy should be weak. This is incompatible with the large bond energy of a vacancy pair, being about two eV. (The assumption that moving a halogen atom from infinity to a vacant anion site would require no energy, has often been made by theoretical workers, including Seitz himself).

2. One would expect $V_3$-centres, on Seitz's model with two cation vacancies, to be less stable than $V_1$-centres, in contradiction to their high thermal stability.

3. It has been shown recently[2] that irradiation, at liquid hydrogen temperature, into their own band converts $V_1$-centres into $H$-centres. This observation makes the relation suggested by Seitz for the afore-mentioned two centres rather improbable.

The respective models proposed by the present author are:




These are based mostly on the observation of some regularities in the absorption band maxima of the several $V$-bands[3].

The maxima for all known $V_1$-bands have nearly the same value for the same halogenide, irrespective of the cation, and this is somewhat less than the electron affinity of the respective halogen atom. Hence the $V_1$-centre is interpreted as an isolated self-trapped hole, stable only at very low temperatures. The optical activation energy is that required for the transfer of an electron from an adjacent halogen ion, polarized by the effective positive charge on the hole, and the net result of the reaction is the diffusion of the hole one lattice space. At liquid hydrogen temperature the lattice ions surrounding the newly

formed hole keep their original position, i.e. no distortion of the lattice occurs. This gives rise to the $H$-band with an absorption peak shorter than that of the $V_1$-band, and which corresponds more nearly to the halogen atom affinity.

The resistance of the $V_3$-centre to bleaching by irradiation into the $F$-band is attributed to the neutrality of this centre and the low cross-section for electron capture accompanying this property.

Absorption of light in the $V_3$-band results in the moving of the hole one lattice space, as well as the dissociation of the neutral pair. Hence the energy corresponding to the peak of the absorption band is equal to the sum of the electron affinity of the respective halogen atom ($E$) and the energy required for the formation of a pair of isolated vacancies ($W_0$).

| | $V_3$ | $E$ | $W_0$ | $E\,W_0$ |
|---|---|---|---|---|
| NaCl | 5.88 | 3.78 | 1.86 | 5.64 |
| KCl | 5.73 | 3.78 | 2.08 | 5.86 |
| RbCl | 5.55 | 3.78 | 1.76 | 5.54 |
| KBr | 5.32 | 3.52 | 1.92 | 5.44 |
| KI | 4.41 | 3.12 | 1.53 | 4.65 |

The $V_2$-centre like the $V_1$-centre has an effective positive charge, but it is more stable than the latter owing to the formation of a stretched covalent bond between the pair of holes (halogen atoms) associated with this centre. Hence the optical activation energy of a $V_2$-centre should be equal to the sum of the activation energy of the respective $V_1$-centre and the energy required for the disruption of the covalent bond ($Dc$). The $Dc$ values thus obtained for KCl and KBr crystals are both less than the bond energies of the respective halogen molecules in their normal state ($Dg$). The comparatively large difference $Dg-Dc$ for KCl may serve to explain Mollwo's unsuccessful attempts to colour KCl by chlorine gas.

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## Measurements of the Hall effect in germanium,

J. Houghton*, P. C. Banbury*, A. Many+ and H. K. Henisch*
*University of Reading and +The Hebrew University of Jerusalem

### *Introduction*

In a previous paper[1] some aspects of the Hall effect were theoretically examined, with reference to the complications arising from the presence of surfaces on specimens of long (bulk) carrier life-time. The conclusions indicated that the presence of surfaces with a low carrier recombination velocity may have an important effect on the measured Hall voltage. This voltage would then be expected to differ from the value calculated on the basis of orthodox (bulk) theory for two reasons: (a) because of the space charges and concentration gradients arising within the material, making the Hall field non-uniform, and (b) because of floating potentials at the (point) Hall electrodes which would be superimposed on the actual Hall emf and which are due to departures from electronic equilibrium in the neighbourhood of these electrodes. Explicit solutions of the relevant equations could not be obtained, but experiments have since been carried out (so far only on $n$-type material) to assess the magnitude of these two contributions.

### *Method of estimating the floating potentials at the Hall electrodes*

The floating potentials which are superimposed on the Hall emf can be estimated by the following procedure. The change of minority carrier concentration responsible for the appearance of the floating emf's also gives rise to a change of point conductance at zero voltage. This change, $\Delta G$, can be measured for each Hall electrode, care being taken to eliminate errors arising from the magneto-resistive effect. Any particular change $\Delta G$ can be regarded as characteristic for a definite change of carrier concentration near the point contact. An increase of carrier concentration makes $\Delta G$ positive, a decrease makes it negative. A positive $\Delta G$ can be alternatively produced by the illumination of a contact. By adjusting the intensity of illumination this change can be made equal to that previously recorded under the influence of the Hall effect. The open-circuit photo-voltage which corresponds to these particular conditions of illumination is then a very good approximation to the floating potential under investigation. The same procedure cannot, of course, be used on a contact for which $\Delta G$ is negative. However, the relation between floating potential and $\Delta G$ can be ascertained in the positive direction for a series of light intensities, and linear extrapolation of this relation into the negative direction would seem permissible, as long as the floating potentials concerned are smaller than $kT/e$. Under such conditions an estimate of both floating potentials can be obtained.

*Magnitude of the floating potentials*

The floating potentials have been measured for a number of unformed tungsten contacts by the method described above. A high contact thrust had to be used in order to ensure adequate sensitivity and stability. Care must be taken in all such experiments to ensure that the application of the Hall probes does not destroy the carrier life-time in the neighbourhood. For this reason, all soldering and welding processes were avoided. It is known from independent experiments that a high contact thrust diminishes the floating potential corresponding to given conditions of illumination. Nevertheless, floating potentials were observed on well etched surfaces, which amount to about 3 per cent or so of the total Hall voltage. With smaller contact thrusts, these potentials could be substantially higher. No conductance changes could be detected on sand-blasted surfaces, nor were they expected, since such surfaces are associated with a very high recombination velocity.

Theoretical considerations predict that $\Delta G$ should be positive on one Hall electrode and negative on the other. The measurements have confirmed this.

*Magnitude of the bulk effect*

There are two aspects of the bulk effect which can be investigated separately. In the first instance, it is to be expected that Hall effect measurements on specimens with well etched surfaces should depend on the exact surface condition and should thus be variable and unstable, unless special precautions are taken. Conversely, measurements on sand-blasted specimens should be repeatable and stable. This is confirmed by the experiments. Moreover, the Hall emf, after elimination of the floating potentials, should be greater for sand-blasted than for well etched surfaces. Differences up to 50% in this direction have been observed in the course of the present measurements. The existence of the bulk effect thus seems well established.

The second aspect concerns the quantitative relation between the bulk effect and such parameters as the surface recombination velocity, the resistivity and bulk life-time of the specimen, and the specimen size. Systematic comparisons of this kind are difficult and laborious, but a few general results are available. Thus, pronounced effects have been observed only on specimens, less than 1 mm in thickness in the direction of the Hall emf. The effects under discussion disappear if the bulk life-time of the material is too low. They have been observed on materials with resistivities between 8 and 23 ohm.cm. It may be of interest to note that difficulties of the kind discussed here are expected to be similarly associated with all other galvano-magnetic measurements on long life-time materials and also with measurements of the thermo-electric effect.

*Acknowledgments*

Thanks are due to Professor R. W. Ditchburn for placing research facilities at the authors' disposal and to the Admiralty for permission to publish this report.

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**Characteristics of the absorption bands due to optical excitation of a CdS crystal,** G.F.J. Garlick and A. Halperin*, *The University of Birmingham, Birmingham, England.* A single crystal of pure, unactivated and non-luminescent cadmium sulphide was submitted to optical measurements. It was found that on excitation with 5461A radiation new absorption bands appear, extending from the lattice absorption edge to about 1.4μ, with a maximum at about 0.77μ. The characteristics of this incremental absorption were investigated, and some of the results are described in short below. It is assumed that trapped electrons (and probably also holes) are responsible for these bands. Thus the origin might be essentially the same as that of absorption due to colour centres known in other crystals (e.g. the alkali halides).

*Spectral distribution of the bands*

Figure 1 shows the absorption spectra produced by excitation of the crystal at room temperature

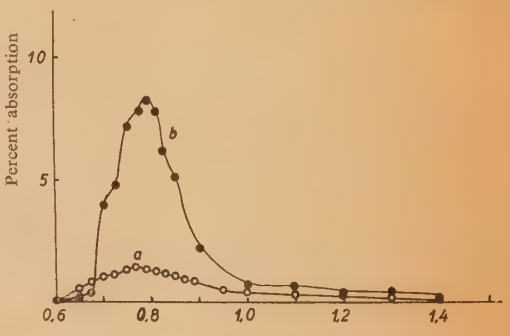


Figure 1
Spectra of incremental absorption due to excitation of a CdS crystal: a) at 290° K, b) at 90° K.

* Now back at the Hebrew University of Jerusalem; the work was carried out while on study leave.

(curve *a*) and at 90°K (curve *b*). As shown in the figure, the intensity of the bands is low at room temperature but reaches some 10% at 90°K, corresponding to maximum absorption coefficient of about $1cm^{-1}$.

*Optical bleaching of the bands*

The measuring beam from the monochromator, used for measuring the absorption, served in these experiments also for bleaching. This means that the effect of bleaching by the monochromatic radiation can only be observed at the same wavelength. The optical bleaching at 0.78$\mu$ and 90°K is shown in Figure 2 by a plot of log $(A_t/A_0)$

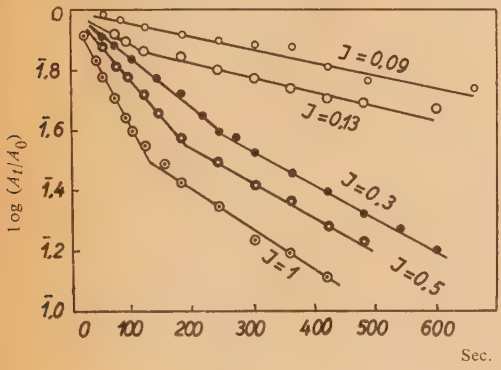


Figure 2

Decay of incremental absorption at 90° K, on bleaching by measuring beams (0.78 $\mu$) of various intensities ($I$). Absorption is expressed as fraction of initial value ($A_0$).

against the time of exposure ($t$), for five different values of the bleaching radiation ($I$). The shape of the curves indicates that this is at least a two stage process, only the initial stage of bleaching being dependent on the intensity of the bleaching radiation. Further experiments on optical bleaching at different wavelengths have shown that three stages of optical bleaching exist with different "resistances" to the bleaching radiation.

*Thermal bleaching of the bands*

The in cremental absorption is stable at 90°K. On warm ing the crystal a temperature is reached at which thermal activation is sufficient to eject electrons from traps when the absorption decreases. Curves showing the fall in absorption with rising temperature provide information about the distribution of the traps in the crystal. If such curves are differentiated with respect to temperature, the derived curves are analogous to the "luminescence glow curves", or "current glow curves" known in experiments on phosphors. The "absorption glow curves" have the advantage that there are no complications due to the luminescence centres involved in the usual glow curves, or due to factors such as the electrons entering the conduction band or mobilities involved in the case of the current glow curves.

Experimentally, certain difficulties arise in measuring the thermal bleaching. On warming the crystal, "absorption" peaks appear, which can be traced to be due to condensed vapour films on the crystal surfaces[1]. These effects could fortunately be minimized, and, after differentiation with respect to temperature of the curves of thermal bleaching, two peaks were obtained in the region 120—400°K, one above 200°K and one at about 330°K. Comparison with "current glow curves" of the same specimen shows correlation, as both peaks appear at the same temperatures, although the peak at above 200°K, which is the strongest in the "absorption glow curve", is hardly noticeable in the "current glow curve" (private communication from D.R. Hamilton of this laboratory).

*Effects of heat treatment*

The band intensities depend on the previous heat treatment of the crystal, increasing after fast cooling from 600°K to 90° K, but being reduced if excitation takes place after annealing at high temperatures followed by slow cooling. This effect is shown in Figure 3. Curve *a* was obtained by cooling the crystal from room temperature to 90°K, curve *b* just as *a*, but was measured after a few months of work on the same crystal. Curve *c* was taken after quenching the crystal from 600°K to 90°K. The intensity of absorption is now increased and, in addition, absorption extends now to shorter wave lengths and peaks again near

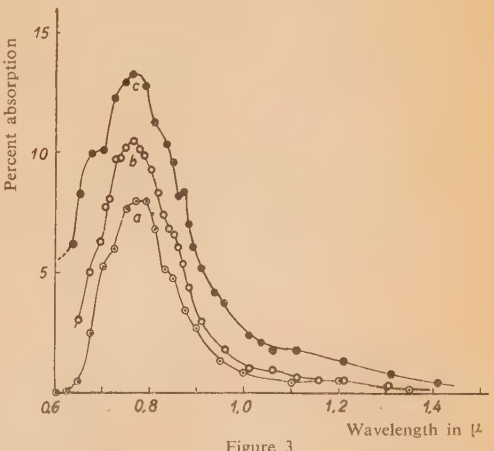


Figure 3

Effect of heat treatment on the incremental absorption at 90° K: a) just as curve *a* in Figure 1; b) the same as obtained a few months later; c) obtained on excitation at 90° K which followed heating to and quenching from 600° K.

the lattice absorption edge at about 0.5$\mu$ (not shown in the figure). Closer examination shows that different parts of the bands are selectively affected by the heat treatment, and that the bands which increase in intensity after quenching are hard to bleach optically.

A fuller report of this investigation and a discussion of the results will be published elsewhere.

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**The photoelectric effect of X-rays in blocking layer photocells,** K. Scharf, *Technion—Israel Institute of Technology, Haifa.* Quantitative measurements of the X-ray photoeffect in blocking-layer photocells previously carried out by the author[1] have shown that $Cu_2O$ and Se photocells behave in a similar manner when irradiated with X-rays as when irradiated with visible light of low intensity. In the light of the present theories of the photovoltaic effect, these measurements lead to the following conclusions.

1. The proportionality of photo-emf and photocurrent to the intensity of the incident X-ray radiation is in accordance with the theories of the photovoltaic effect [2,3,4,5] for the case of small light intensities.

2. As in the case of observations with visible light, changes of the photocurrent with changing angle of incidence of the X-ray radiation do not follow the cosine-law. No satisfactory explanation could be found for this effect.

3. Photo-emf and photocurrent, referred to the same energy of incident radiation but of varying wavelength, are proportional to the X-ray absorption coefficient $\tau$ of the photocell for small values of $\tau$, i.e. proportional to the absorbed energy of radiation.

This spectral response is in accordance with the theory of Lehovec[4], if one assumes that only a very thin layer is responsible for the photoelectric effective absorption. The observed photo-effect, if referred to the same quantity of absorbed energy, must be independent of the frequency of the incident X-ray radiation.

4. The quantum-equivalent, given as the number of photoelectrically measured electrons per absorbed X-ray photon, appears therefore to be proportional to $h\nu$. The average energy received by each electron is the same for different frequencies of radiation.

From the above measurements[1] it has been shown for $Cu_2O$ cells that the photo-effect referred to the same absorbed energy is independent of $\nu$, if the thickness of the absorbing $Cu_2O$-layer is assumed to be $10^{-5} - 10^{-6}$ cm. In this case the above defined quantum-equivalent is of the order of $10^5$ electrons per absorbed X-ray photon, giving an average energy received by an electron of approximately 0.3 ev.

5. Se photocells show a decay of photo-emf and photocurrent with time of irradiation and a decaying dark current after cutting off the radiation. In both cases the decay follows a power law.

Previous irradiation with visible light reduces the size and decay rate of the photoeffect during the following X-ray irradiation. The dark currents are nearly the same for different intensities of the preceding X-ray irradiation, which vary over a range of a factor of 10.

This behaviour of Se photocells indicates the existence of electron traps inside the blocking layer. If these traps are assumed to be surface trapping states, the filling of these traps would decrease the potential barrier in the blocking layer, thus decreasing the internal field and thickness of the layer. The photoeffect will therefore be decreased, while the conductivity of the layer and the capacity of the cell will be increased, as has been observed in Se cells in investigations with visible light.

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